After Discovery: What Next? ■ Rush Week at Space U ■ Facing the Face on Mars ■ How to Become A Shuttle Astronaut ■ Cosmic Jukebox ■ E.T. Contest Winners ■ Robonauts ■

FINAL FRONTIER

The Magazine of Space Exploration

December 1988 USA $2.95/OTHER $3.95

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BOEING

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November/December 1988
Volume 1, Number 5

We went, we saw, we conquered—and soon we'll return. See the special section on the Moon, beginning on page 17.

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FROM THE PUBLISHER

How high the moon
—a song by Hamilton and Lewis

That says it all, as far as I'm concerned: How high the Moon. It's not a question. It's not an exclamation. It's a shake-your-head-in-wonder kind of proclamation.

There it is, swinging 'round our heads, night and day, the symbol of everything just out of reach. The Moon.

For one shining moment, though, we touched it, didn't we? 1969. And we even went back. A dozen of us hopped, worked, sang and even played golf on that weird, alien world. Then we stopped going, and the Moon fell silent once more.

And there it still is, staring back at us in...what? Bemusement, wonder, aloofness, longing? How high the Moon....

We've got stuff up there in that celestial pawnshop—high-tech mementos dropped in our hurry to leave nearly two decades ago. Now our claim ticket is getting yellow and frayed around the edges. We take it out and look at it once in a while, and that's what this Moon issue amounts to—a little nostalgia for some family heirlooms left behind.

It started when we took Ralph Cramden's advice and went to the Moon back in 1958. Pioneer 1. The name fits perfectly. Those were the years before our beautiful bureaucracy. Back when you said "go," and things went.

It took another ten years to come up with the tools and the gumption to send human pioneers. But they made it, before the decade was out, in *grand style*. And now the rest of us are thinking about following in their Moon-booted footsteps.

When I read Discovery astronaut Dave Hilmers' piece in "The Observatory" this month, I had to laugh. He claims that we've failed if we can't put large groups of plain folk into space within 20 years. Less adventurous people might say he's just dreaming. But that's a big part of this magazine's job, if you ask me.

Call us retro, but we to had to do it. We had to do the Moon issue. Sure, we know that *other folks* are planning their Mars itinerary. We hope to join them there, too.

But we were thumbing that old claim ticket, and we started thinking ahead to the day when they'll ask, "How high the Moon?"

And we'll answer, "Not really that high at all."

Ever upward,

William Rooney

William Rooney
Publisher

FINAL FRONTIER

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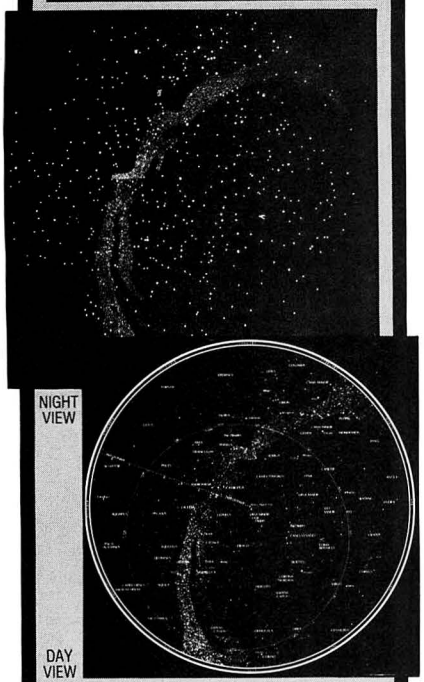

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LETTERS

TOM R. GARRETT

The Last Schirra

Walter M. Schirra ("The Observatory" August 1988) ought to step away from the mirror and quit admiring his "scarf and goggles" long enough to realize that Earth orbit has not yet been deeded to test pilots. True, if the U.S. is to be a world leader in space technology and commerce, we must make a serious commitment to human presence in orbit. However, achieving that commitment has much to do with establishing achievable goals, and little, if any, to do with who goes along for the missions.

The public expects more from its space program than cosmic barnstorming. In attempting to reserve space flight for test pilots, Mr. Schirra ignores the significant contributions of countless scientist/astronauts who have joined the ranks since he was selected in 1959. From Apollo expeditions to experiments on the space shuttle, America has gained overwhelming returns from those whose assignments on flights were geared to gaining knowledge and advancing science.

The implication that the public would not have received "more in return than the cost of sending...a school teacher up" ignores the importance that space flight can play in the educational community. The educational benefits to the nation from the planned Teacher in Space activities will far exceed whatever "cost" may be involved. For a country that has become increasingly reliant on science and advanced technology, it is imperative that we motivate young people and produce the high caliber scientists, engineers, technicians, social scientists, humanists, and yes, even test pilots, who will lead and manage America's space program in the 21st century.

The nation's space leadership objectives go beyond testing vehicles in orbit. In order to achieve safely the goals of our future exploration missions and the concerns raised by Mr. Schirra, NASA has implemented procedures to satisfy the many recommendations of the Rogers Commission. Managing a system as complex as the National Space Transportation System and delivering its benefits to the public require the skills and expertise of a wide range of professions and disciplines in addition to the test pilots.

Alan Ladwig
NASA Office of Exploration
Washington, D.C.

Off the Mark

The article on American Rocket Company in the August issue of FINAL FRONTIER contained a number of glaring factual errors...Given your stated desire to specialize in space-related topics, this alone is an embarrassment.

More disappointing is the tenor of the article. Your writer has relied heavily on former AMROC employees in framing her piece...including the former Chief Financial Officer who "cleaned out his desk" when we wouldn't fold up and die. His remarks continue the divisive behavior which characterized his short stay at AMROC.

The team that has kept AMROC going feels that this article's tone and characterization of our venture is as far off the mark as your statements of the "facts."

George A. Koopman
President American Rocket Company

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THE OBSERVATORY

After Discovery

For almost three years, the U.S. space program focused on the all-important task of returning the space shuttle to flight. But what about after Discovery? What should be our new goals in the second shuttle era? Earlier this year, as astronaut Dave Hilmers and his STS-26 crewmates prepared for Discovery's return to space, he expressed these thoughts in a NASA radio interview.

Let's keep up the enthusiasm!

▼ ▼ ▼

By Dave Hilmers

A successful flight means that STS-27 is now the most important mission in the future of the space program. We cannot afford an early failure such as we had [with Challenger] on 51-L. The important thing is that we keep our guard up, that we keep up the type of scrutiny we've had for STS-26.

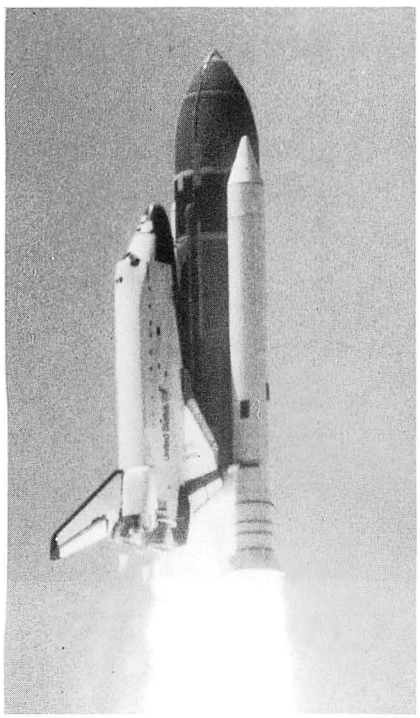
A long string of successful missions is really the most critical thing to our space program right now. Long-term goals all depend upon the fact that the shuttle is a viable option, that it's working, and that it will be able to support projects such as the space station. Without the shuttle working properly, the space station can never happen...

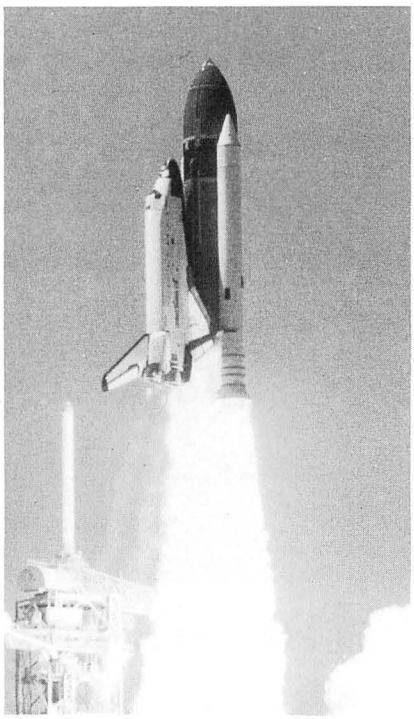
...Young people realize the same thing that I see: this really means the future of our country. Are we willing to take risks and proceed ahead, or are we willing to let a setback keep us from progressing farther in technology, science and the exploration of the universe? And the message from these kids is that, "We really think this is important. We're behind you, and we want to take part in this someday"...

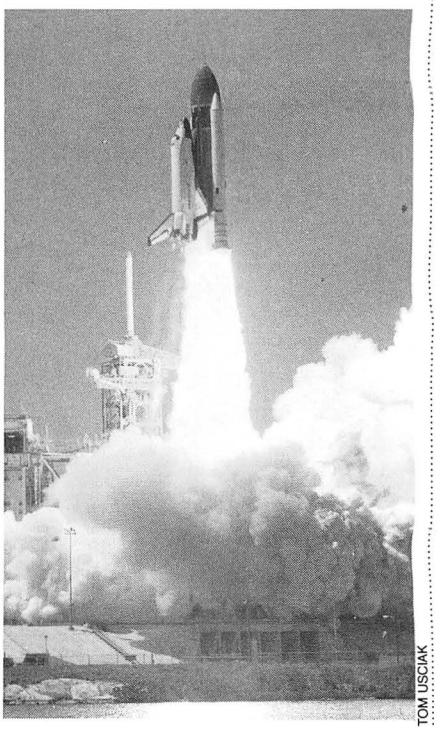
...I'd like to ask people to maintain the level of enthusiasm that we have now. I think everyone saw with 51-L what can happen to the program. As [we] progressed from STS-1 to our 25th flight, we saw the enthusiasm maybe start to go down a little bit, maybe because people perceived that we'd *done* it—it's now an operational vehicle, it's something that we don't have to worry about anymore, it's something that we can take for granted. If we want to maintain these long-term goals, we're going to have to keep up the same level of enthusiasm about the shuttle program—not only for the first mission, but through many missions.

I think it's important for people to remember that [the shuttle is] always going to be a vehicle that has some risk. As we look toward the future, if we never get to the point at which we can reliably and safely bring a large number of people—ordinary citizens—into space, then we've failed; if, say, within 20 years that isn't a reality. But for now there are risks; and hopefully, as we have more and more launches, we'll learn more about getting into space, about our current systems.

As we design follow-on systems, the risk will go down, just as it did with airplanes as we learned more about aerodynamics and aircraft. Hopefully, the same thing will happen as we talk about going into space. □







TOM USCIAK

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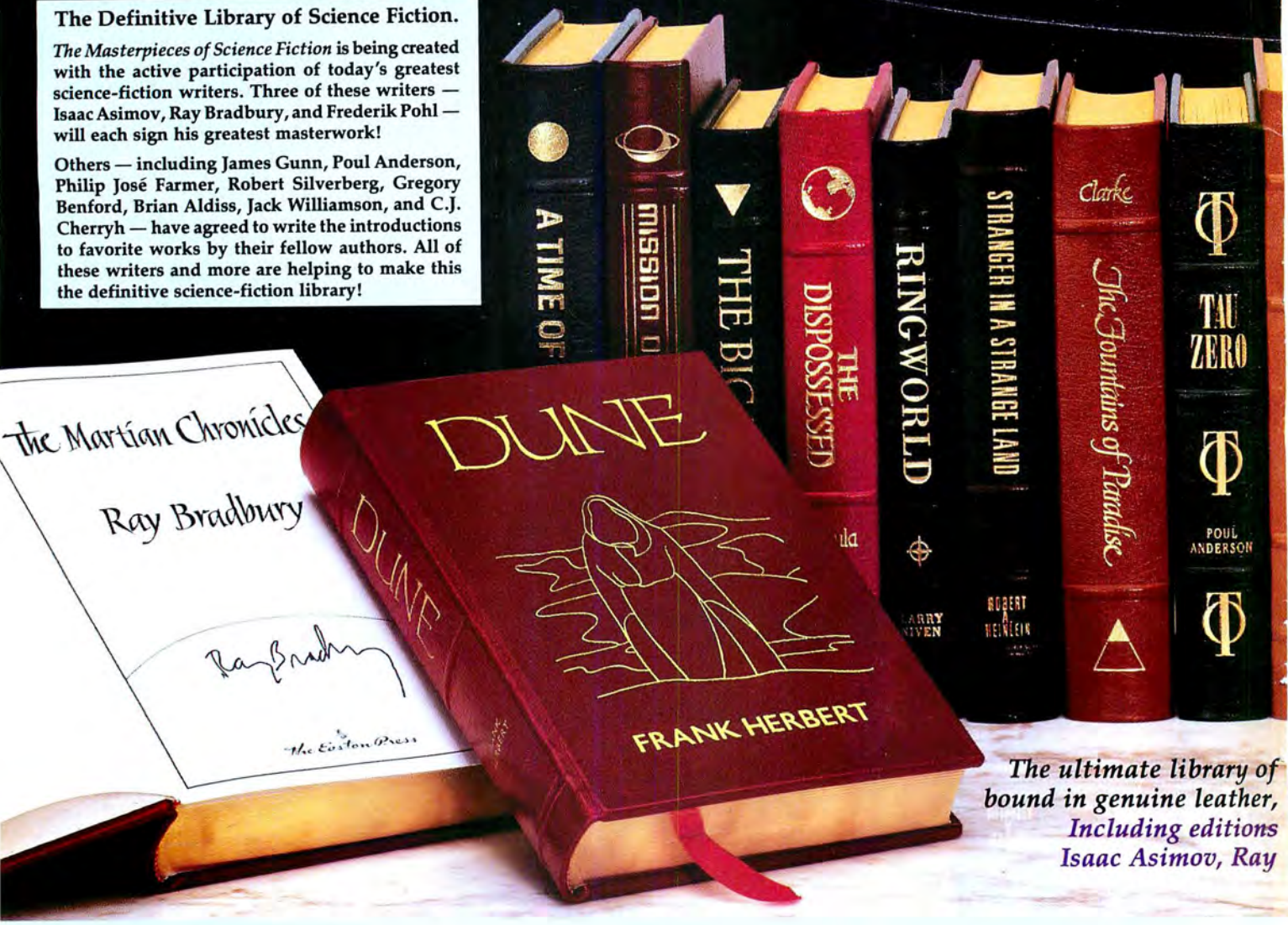

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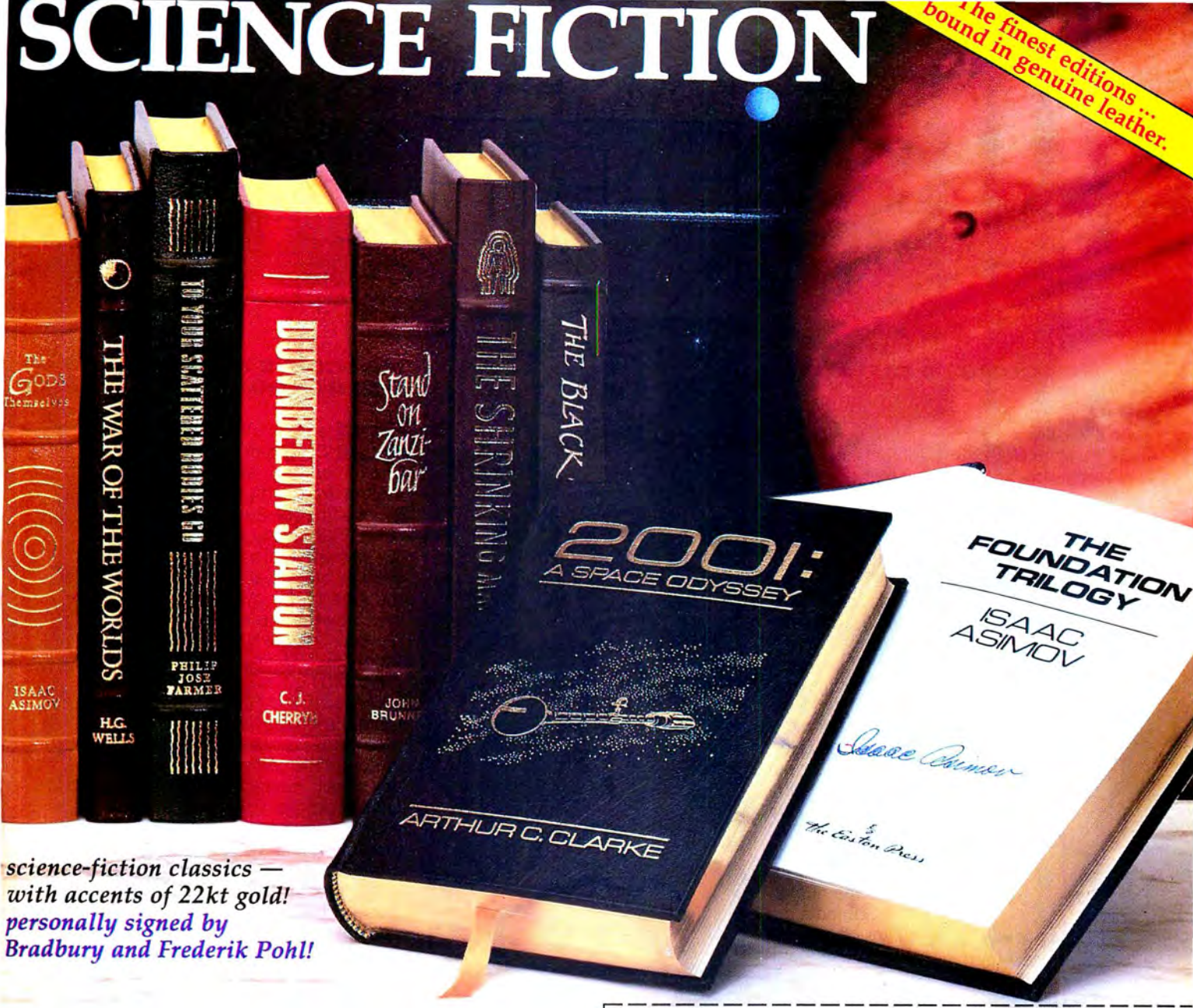

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NOTES FROM EARTH


TOM R. GARRETT

WELCOME TO CLUB BED

With mottos like "we got our kicks at negative six," volunteers for NASA's bed rest studies in Houston and at the Ames Research Center in California are a brave, patient, stalwart bunch. They write songs like "The Bed Rest Blues" and playfully tout the accommodations of "Club Bed."

But the tests themselves are no joke. NASA doctors have found that the prolonged inactivity of "head downward" bed rest simulates some of the physiological effects of zero-g. The studies, performed under controlled conditions, may help answer questions about what working and living in space does to the human body. Subjects try various forms of exercise, use medication and undergo muscle and bone biopsies, all while lying down. The inactivity lasts as long as thirty days, sometimes as few as seven or eight.


NASA

NASA bed rest study volunteer Sam Kampschmidt lays himself down for science.

Why do these human guinea pigs let their well-trained muscles grow flabby and their minds go stale? Why would anyone want a horizontal "car-wash" shower to be the high point of their day?

Most of them, like Sam Kampschmidt, enjoy the idea of being surrogate astronauts. "They're my heroes," Kampschmidt explained from a small, hospital-like ward at Ames, his head tilted downward at a six degree angle. A competitive swimmer and student of physical therapy, Kampschmidt admits that he suffers withdrawal from his usual active routine. And when the study is over, it takes him a full two to three months even to begin to get back to normal.

After three consecutive summers, he says, the fun of being a bed rest subject has begun to wear a little thin. Irritability sets in after a few days, even among the laid-back subjects carefully picked for these studies.

But it's not all bad. Program Director Dee O'Hara keeps morale high by regaling her charges with tales of the original Mercury astronauts, and of the days when she was head nurse for the Apollo Moon program. Kampschmidt also notes that the group quickly develops a strong team spirit.

"We all root for each other. You learn something about what it means to be dependent, unable to get up or do almost anything for yourself. You learn some things about your own body. You slow down."

And, he adds, when you first walk outside after it's over, the world seems miraculously transformed, somehow fresher, newer—and wonderfully free.

—Ray Spangenburg and Diane Moser

MOSCOW'S FLYING BILLBOARDS

Representatives of two Western European steel companies, Danieli of Italy and Voest-Alpine of Austria, watched proudly as the Soviet Union's Phobos 2 spacecraft roared off on its 200-day journey to Mars last July 12 ("Mission to Phobos," June 1988). In splashy orange and black lettering on the side of the mighty Proton launch vehicle were the names and logos of the two firms, who had signed on as "sponsors" of Phobos 2.

According to Soviet and U.S. sources, those two "sponsors" were more than happy to pay a fee to have their names on the sides of the booster. Although the companies say they have no direct contacts with the Soviet space program, Danieli and Voest-Alpine have worked together on other projects with the Soviet Union, so they ponied up the fee to send their names and logos into space. Other companies invited by the Soviets were content to keep their advertising down to Earth, and put their ads on boards near the launch pad.

How do American companies feel about the Russians selling ads on their space vehicles? A public relations spokesperson at Martin Marietta, whose company builds the Titan commercial launcher, said Martin would not sell advertising space on its rockets. The company will allow only its logo and the logos of subcontractors who have systems on the Titan or who have sponsored payloads. The race for advertising space on boosters is "not something that concerns us," he said.

Over the years, NASA has received several proposals to sell advertising space on launch vehicles, spacecraft and platforms around the launch pad. The agency nixed all of them.

A NASA source said that one of the big reasons for the turndown was all the flak the agency got from the U.S. media: "We even got a proposal for corporate logos on the countdown clock at the Kennedy Space Center. The television networks said they'd

never show the clock."

In a press release about the Phobos probe, the Soviets reminded us that "...one of the theories by Soviet astrophysicist Losif Shklovskii suggested that the Martian satellite(s) were artificial in origin." So it only seems right that ads should be sold on a vehicle headed toward what could be a Martian advertising gimmick. When the first transmission comes back from Phobos, it may be a Martian television commercial.

And the Russians got there first.

—Robert Moulton

AND HOW DO YOU BOIL THE WATER?

Maybe you remember the opening scenes in *The World According to Garp,* where a gurgling baby "floats" across the movie screen. Perhaps it's the director's statement. Or a case of art imitating life.

Ruth Tucker says it's an indication of things to come.

"Astronauts living away from Earth for extended periods may want their families to join them," explains Tucker, an R.N. and Ph.D. at the University of Texas at Galveston. "Maybe a woman astronaut will not want to delay childbearing for her career. Either way, we're likely to see childbirth in space."

Tucker presented these possibilities last spring during the "First National Conference on Nursing In Space," held at the University of Alabama in Huntsville. The first-of-its-kind symposium was co-sponsored by the university, Sigma Theta Tau nursing society and NASA.

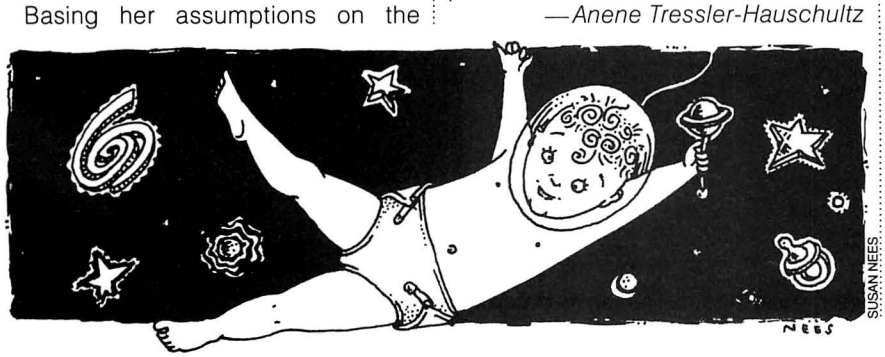
Basing her assumptions on the known physiological changes associated with space travel and Earthbound pregnancy, Tucker paints an interesting future. "We know that weightlessness causes a decrease in blood volume and heart size. It also causes a fluid shift from the legs to the head. These conditions might offset the cardiovascular changes experienced by pregnant women. They might even eliminate the foot swelling, varicose veins and back pain which often accompany pregnancy."

Once labor begins, the challenges become interesting. "Gravity plays a role in the delivery process," Tucker points out. "It also affects pain medications." The use of local anesthetics might be impractical, Tucker says, because "these medications settle in the pelvic region (due to gravity) where they are needed. We couldn't expect this to take place in space."

Other barriers involve the limitations of room, weight load and supplies. Tucker notes that pregnant women consume greater amounts of oxygen during their pregnancies and increase their oxygen consumption 100% during labor and delivery. She adds that the physical changes of pregnancy might also demand an expandable flight suit, and passageways large enough to accommodate a pregnant woman's changing silhouette.

Tucker admits that the first "space age delivery" is probably several decades away. "But it will happen, sooner or later," she says. "Pregnancy in space will differ from pregnancy on Earth. What we need to find out is exactly *how* it will differ, and what we can do to prepare for it."

—Anene Tressler-Hauschultz



SUSAN NEES

CHARLES J. DIVINE

A BALLET FOR CHALLENGER

Like many people who grew up during the 1960s, Dermot Burke saw the early astronauts as heroes. Even as he later followed artistic dreams—principal dancer with the Joffrey Ballet, director of the professional company at the Princeton Ballet School—Burke remained fascinated with space and the exploration of the unknown.

The Challenger disaster profoundly affected him, and to express his feelings Burke chose the medium where his greatest talent lay. Last year he choreographed a new work for the Princeton Ballet, titled simply *A Tribute*, which pays homage to the Challenger crew by portraying the trek into space as a hopeful, uplifting experience.

"We should mourn the fact that the Challenger astronauts are not here, but we should also be grateful that there *are* such people," says Burke. "They were noble, brave, curious risk takers who embraced their destiny."

In creating *A Tribute*—which will be performed by the Princeton Ballet again this season—Burke used a series of risky turns. He had the dancers open their arms upward and lean their upper bodies backward as if to peer into the heavens.

"The steps they are trying to execute are right on the edge; that's part of what denotes the risk and danger," says Burke. "I think the dancers are touched. I see the way (their eyes) tear up."

After the original seven dancers leave the stage, the ballet concludes with a lone figure representing all of us who watched Challenger meet its fate. She must mentally process in a very few moments the reality the rest of us have had months to comprehend.

"The dancer sees the flash, and tries to run away," Burke explains. "But she collects her thoughts—and finally does the same steps that started the ballet. She's carrying on.

"I want people to be pulled into that moment." *—Charles J. Divine*

NOTES FROM EARTH

SPACE STATION: FREEDOM REIGNS

Along with its political and budgetary woes, NASA's space station program has always been stuck with a bland, generic handle that only an engineer could love: "Space Station." But that changed in July, when President Reagan chose the name "Freedom" to be emblazoned on the station's helm when the spacebase is launched in the 1990s.

It was by no means a quick decision. After the space station's inception in 1984, proposed names flowed into NASA from across the country. The station project office finally acted last April, forming a Space Station Name Committee to review the various suggestions. NASA employees and contractors were then asked in a letter—published in several newspapers and magazines, so the public could also participate—to choose one of 16 names or to propose their own title in a space marked "other."

"Other" proved to be the most popular choice. NASA was inundated with over 700 suggested names, ranging from Beagle to Hamlet to Wernher von Braun. Names like Empire and Guardian vied with submissions such as Mom, Night Crawler and Shangri-la.

Another committee reviewed the titles, searching for a name that was simple, easily translatable and suggestive of the station's international sponsorship. The final contenders—Pegasus, Freedom, Friendship, Orion, Aurora, Olympia and Odyssey—went

ERIC HANSON

to NASA Administrator James Fletcher, who chose Freedom, then passed his recommendation to President Reagan, who had the final say.

Adam Gruen, the 29-year-old historian who first suggested the name "Freedom," said his title contrasts with the "one world, one government" concept implied by the Soviet Union's name for its space station: Mir, which translates either as "peace" or "world." "Freedom," said Gruen, "embodied the spirit of the Western democracies involved in the space station project," and also signified "freedom from the confines of gravity."

Gruen was surprised that he was the only one to suggest the station be called Freedom. "After all," he said, "it seemed like a pretty obvious choice."

He also was a bit embarrassed. "I often joke with my friends that, as an historian, it's my job to observe but not to participate in the program (Gruen has a NASA contract to serve as the space station project historian.) And here I've managed to interfere with the natural course of history."

—Gary Stephenson and Miles Weiss

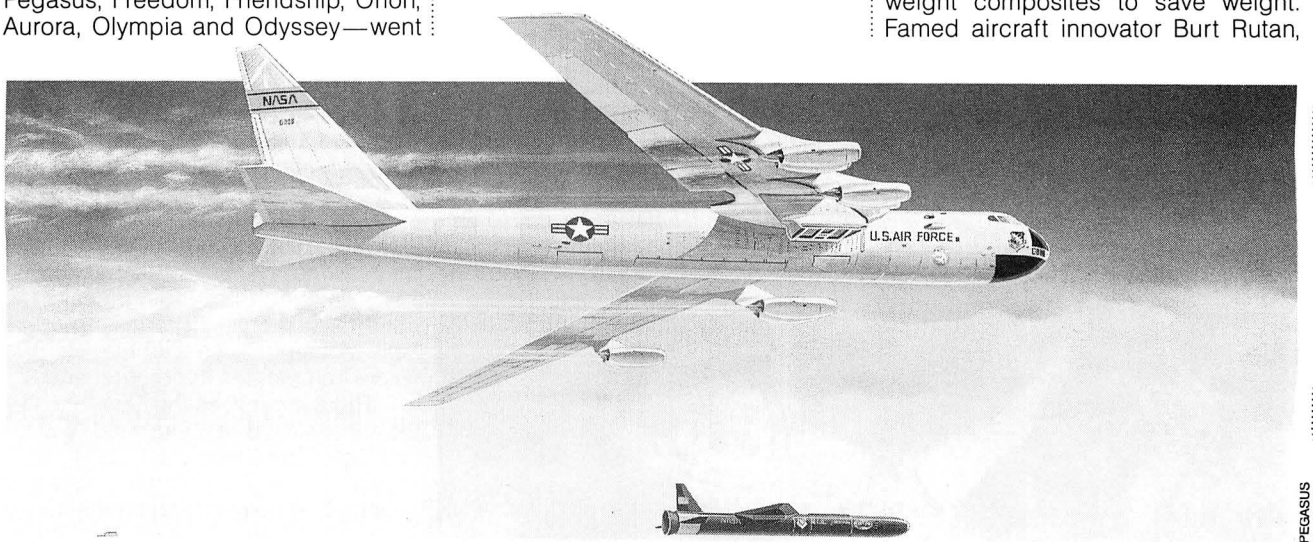
A WINGED WORKHORSE

America's newest launch vehicle has more in common with the old X-15 rocket plane than with the traditional rockets that have launched everything from astronauts to Mars probes in the past 30 years.

Aptly named Pegasus, the delta-winged launcher will be fired like a missile from beneath the wing of a high-flying B-52 bomber, just like the X-15 manned research plane of the 1960s. Pegasus, however, is designed to carry small and medium-weight satellites into orbit for profit.

A joint venture of the Orbital Sciences Corporation (OSC) and the Hercules Aerospace Company, Pegasus is the first completely new American throwaway launch vehicle in 20 years, according to OSC senior vice president Scott Webster.

Three state-of-the-art solid rocket motors power Pegasus, and the 49-foot booster makes extensive use of lightweight composites to save weight. Famed aircraft innovator Burt Rutan,



PEGASUS

Above: A B-52 bomber sends Pegasus spaceward. Opposite page: remnants of Cap Canaveral's first technicians.

who pioneered the use of composites in the round-the-world Voyager aircraft and other projects, is the designer of Pegasus' wings and fins.

Because it starts from an altitude of 40,000 feet and doesn't have to push through the densest part of the atmosphere, Pegasus has twice the payload capacity of traditional ground-launched rockets. It can hurl 600 pounds into a 250-mile-high polar orbit, or 800 pounds to the same altitude above the equator. Launch schedules may also be easier to maintain; Pegasus' designers claim the craft can be carried *above* storms that would ground most rocket boosters.

Pegasus initially will be marketed to the military, which wants a way to loft small satellites into orbit quickly and discreetly. OSC president David Thompson projects 10-15 missions per year, though he expects that the launch vehicle could be a paying concern with as few as five missions annually.

Pegasus' first test flight is scheduled for next summer, when it will carry a data relay satellite into space for the Defense Advanced Research Projects Agency (DARPA) at a cost of $6 million. The unmanned vehicle will even have a touch of the Right Stuff: Ex-astronaut Gordon Fullerton has been tapped to pilot the B-52 mother ship for the first six flights. *—Robert G. Nichols*

DAYS OF FUTURE PAST

Earlier this year, archaeologists reached into the past at the same place where space science reaches into the future. In a citrus grove a few miles from the launch pads at Florida's Kennedy Space Center, they found the remains of a rare coastal campsite that natives inhabited as long ago as 4,000 years.

Jacksonville archaeologist Bob Johnson and his ten-person crew were elated when they unearthed shards of some of the oldest known pottery in the United States: clay vessels tempered with plant fiber, probably made between 500 B.C. and 1,500 A.D. Johnson expected the find to help write the books on the history of Florida's late archaic, or St. Johns, cultural period.

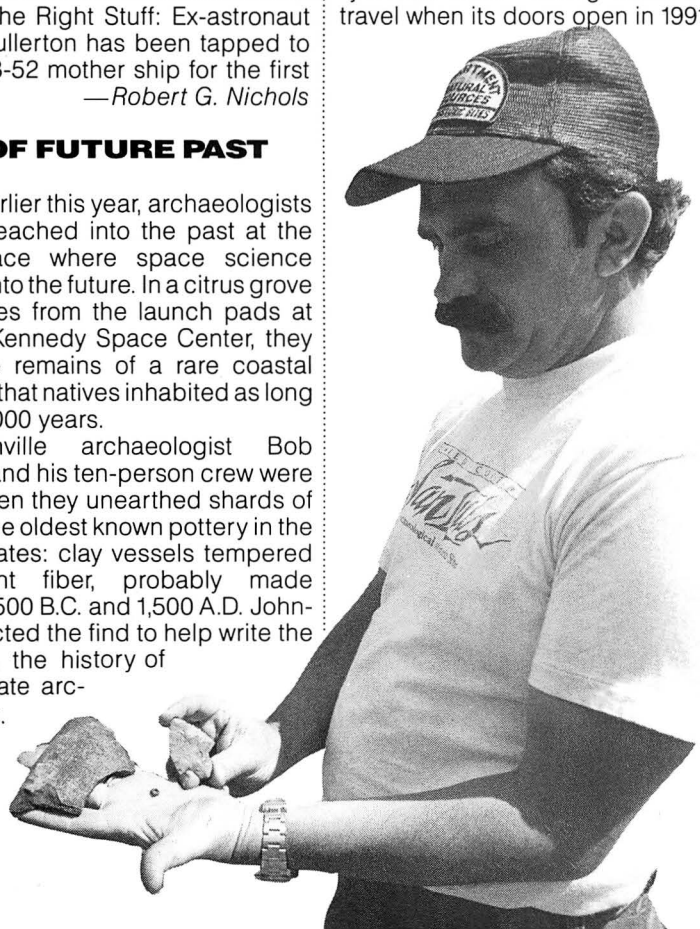
NASA bulldozed the grove and built a new shuttle launch viewing area for VIPs, but only after they had the land excavated to comply with federal historic preservation laws.

The dig unearthed another oddity, not far from where NASA biologists are developing crops that could feed the inhabitants of a Moon base or a Mars colony. Among the hundreds of thousands of artifacts at the site, the archaeologists turned up a number of charred beans. Like the NASA researchers, these forgotten people may have been concerned with feeding future generations. By studying the beans and other well-preserved campfire remains, Johnson speculated, scientists might be able to "pick up some record of early plant domestication. If we do document it, then this will be a *really* significant find."

—Beth Dickey

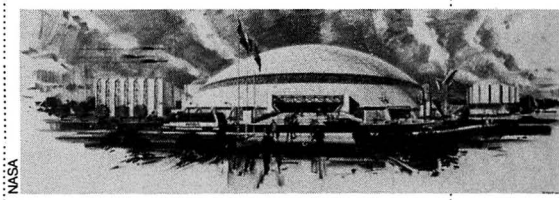
LET'S GET REAL

Hal Stall is wild about reality. It's the guiding concept behind Space Center Houston, which Stall hopes will give visitors an authentic, "you are there" feeling about space travel when its doors open in 1991.



NASA

"Most people's impressions of space travel are based on fantasy and science fiction," says Stall. In contrast, Space Center Houston will offer a realistic simulation of what it feels like to be an astronaut, along with plenty of actual space artifacts. Stall's Manned Space Flight Education Foundation, Inc. has even contracted Walt Disney Imagineering to design exhibits—make that *attractions*—for the new center that will sweep gravity-bound visitors off their collective feet.



NASA

Space Center Houston, opening in 1991.

Project officials claim that the center, which will be built on a 40-acre lot adjacent to the main entrance of NASA's Johnson Space Center, will be like nothing you've ever seen. If you *have* seen it before, "it's not what we're looking for," says Bob Rogers, creative director of the project.

An anticipated two million visitors a year (twice the number the NASA center accommodates now) will be invited to see what astronauts really do, to feel what being in space is really like. The real-life adventures will include operating Manned Maneuvering Units, or "Buck Rogers backpacks," over air-bearing floors that make hoisting seven-ton satellites as easy for wimps as for weightlifters. Visitors also will go inside a "mission control" room; be surrounded by films projected in a large-format theatre; and put their hands on an actual lunar module and a four-story high Skylab spacecraft.

The financially self-sustaining center will receive no federal funding and will raise most of the construction costs (estimated at between $40 and $60 million) from private capital and the sale of long-term revenue bonds. Admission will be about the price of a movie ticket.

Rather than charming its guests with fantasy and imagination, the center wants to wow them with reality. "What we're doing in space is so exciting we don't need to build it up," Stall says.

—Kathleen A. McCarthy

NASA 30 years

Launching the Aspirations of a Nation

NASA, established
October 1, 1958,
launched its first
spacecraft, Pioneer 1,
October 11, 1958,
built by TRW

TRW

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SHOOTING THE MOON

NASA

That ol' devil Moon...

It's been praised by poets and wailed at by witches. It holds sway over the tides and (some say) the birth of babies, and its cycles mark the intervals between holy days. The Romans believed that the souls of dead nobles walked its surface, and the Incas of the sixteenth century would sound horns and beat drums during lunar eclipses to wake the Moon from its dream. Then Galileo's telescope showed it to be neither a spirit nor a perfect crystal sphere, but another *place,* with "vast protuberances, deep chasms and sinuosities." We began to imagine lunar beings—blue unicorns and bat-winged humanoids. ■ And we dreamed about going there. By 1958 we were ready to take the dare, and we shot our first space-age arrows at the Moon ("Pioneers," page 18). A decade later the first interplanetary tourists gazed out on its rough, battered face through the dirty windows of their Apollo 8 capsule ("Leaving Home," page 22). Eight more expeditions followed close behind, scattering signs of life—abandoned Moon-buggies, feathers, golf balls and family photographs—in the lunar dust. Which left us with dreams of returning. ■ We'll go back to the Moon, this time to stay. There are too many mysteries yet to be solved ("The Search for a Lunar Oasis," page 28). The Moon is too close physically, too close technologically, too close to our species' ancient dreams, for us to stay away very long. ■ Its pull is just too powerful to resist.

1958

SHOOTING THE MOON

Pioneers

At the dawn of the Space Age, a hardy band of explorers set their sights on the Moon. They almost made it.

▼ ▼ ▼

BY T.A. HEPPENHEIMER

This is not science fiction. This is a sober, realistic presentation prepared by leading scientists." With these words, the President of the United States committed his nation to a race against the Soviets to become the first country to launch a rocket to the Moon.

But the year wasn't 1961, and the president wasn't John F. Kennedy.

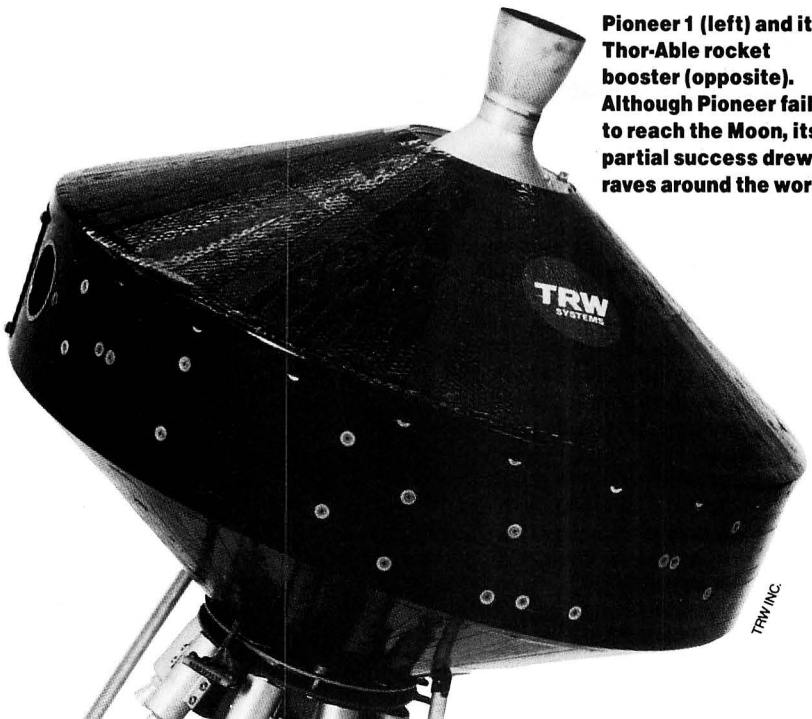
It was Dwight Eisenhower, speaking in March 1958, less than two months after Wernher von Braun had succeeded in launching the first American satellite into orbit. And the proposed Moon shot would not take place, Kennedy-fashion, "before this decade is out." Rather, if all went well, we would have a spacecraft in lunar orbit before the summer was out.

That was 30 years ago, and the spacecraft was called Pioneer 1. Amid the drama of the later Apollo flights, it would soon be relegated to the dusty attic of national memory. No astronauts would hail its name and no vast structures would remain at Cape Canaveral as monuments to its audacity. Yet Pioneer 1 deserves to be remembered, and not merely because it was the first. Amid the doubt and drift of today's space program, Pioneer 1 reminds us of an era when space program leaders had the freedom to act quickly, when the world was young and all things seemed possible.

The Russians had beaten us into space with Sputnik, and with Washington still shell-shocked, anyone with a solid idea for a space success was given the chance to run with it. There was little bureaucracy to bar the way; the space program was in the hands of a small group of people who were accustomed to working together. Nor was there time for extensive development of new launch vehicles or spacecraft. Better to get a rocket on the launch pad, stick someone's instrument package on top of it, and go, go, go.

Von Braun had already shown what could be done in this "don't wait" climate. He'd been ready to launch a satellite as early as 1956, and after Sputnik went up in October 1957, Von Braun had needed only 84 days to put the first U.S. spacecraft, Explorer 1, into orbit.

The Air Force was then building the big rockets, however, and its leading missile man, General Bernard Schriever, was already looking ahead to a shot at the Moon. Working closely with him was a civilian division of the Ramo-Wooldridge Corporation—later



TRW INC.

Pioneer 1 (left) and its Thor-Able rocket booster (opposite). Although Pioneer failed to reach the Moon, its partial success drew raves around the world.

NASA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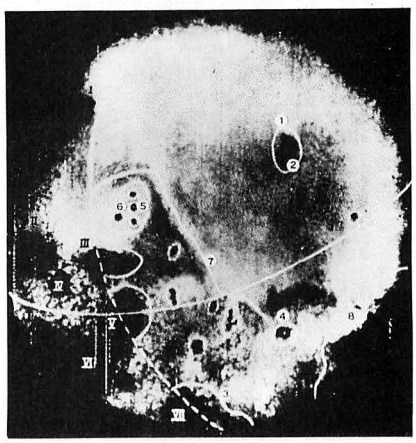


U.S. AIR FORCE

The Soviet Luna 3 took the first pictures of the Moon's hidden side. Pioneer 1 (below) also carried a crude TV camera.

to become TRW—known as the Space Technology Laboratories. While Sputnik was still beeping overhead, STL's Executive Vice President, Louis Dunn, was shaping serious plans for an equally dramatic U.S. response.

The most advanced of General Schriever's rockets, the Thor, had a range of 2000 miles. Experimental versions were flying regularly and were blowing up nearly as regularly, but that was considered part of the business in 1957. Indeed, Dunn had enough confidence in Thor's success to count on using it as the first stage in a more advanced rocket. The second stage, called Able, was to come from the Vanguard satellite-launching rocket, and was still several months away from its first flight. Dunn's team already had laid plans to launch Thor-Ables over distances of 5,500 miles, with experimental nose cones to overcome the blazing heat of re-entering the atmosphere. Inside the nose cone would be a live mouse, wired with sensors.

But with Sputnik overhead, Dunn started thinking more boldly. Vanguard, after all, was a three-stage rocket. What if he were to put both upper stages, not just the second stage, on top of a Thor? The resulting rocket, he knew, would have enough oomph to toss a spacecraft at the Moon. By putting a small retro-rocket onboard, it might actually be possible to *orbit* the Moon.

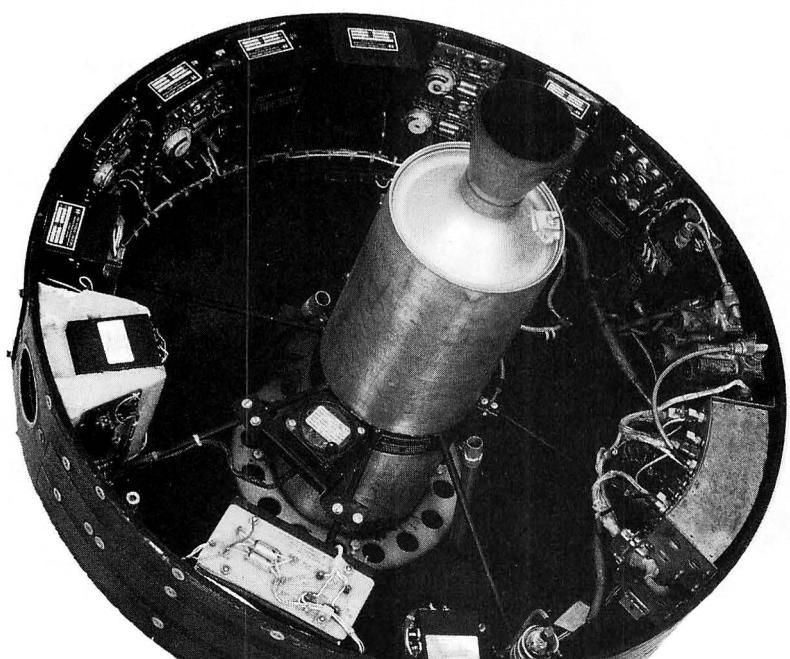
The day before Thanksgiving 1957, Schriever gave his approval to the Thor-Able nose cone tests. In late March, Eisenhower okayed the Moon-shot effort, and Schriever told Dunn to proceed. His order was direct and to the point: "Produce a vehicle that will traverse the distance to the Moon and go into orbit around it."

Dunn was equally direct. As he later told *Time* magazine, "I got all our people together and told them that we had taken on a new job, and that in many ways it represented the biggest challenge we had ever faced....That meant, among other things, that the 40-hour week was out the window. And I thought I'd better be honest about it right then and there, so I also told them that it would be impossible to pay overtime, that we would have to do most of this on our own time."

The Space Technologies Laboratory had less than six months to build their three-stage launcher, design and build a satellite to orbit the Moon, and set up a worldwide network of ground stations to track the satellite in flight. And the STL people would have to do most of this with slide rules; their only computer was a vacuum tube IBM 704 with roughly the power of one of today's hand-held programmable calculators.

In those pioneering days, Dunn's group encountered for the first time many of the problems that routinely face rocketeers today. One potentially sticky concern was the launch time. The STL computer had calculated that the spacecraft would have to be launched within a narrow, 13-minute window in order to meet its appointment with the Moon. But in 1958, it was all anyone could do to get a Thor to fly within any given week!

So one of Dunn's people, George Gleghorn, sat down with his vice-president, Bob Bennett. "Good heavens," they said. "They *always have* a hold in the countdown—let's schedule one!" This "built-in hold," a scheduled interruption to give technicians extra time to fix problems, became standard procedure for all subsequent lunar and planetary missions.



TRW INC.

The Thor-Able, meanwhile, scored a brilliant success on its second test flight in early July. Both stages worked, the experimental nose cone went the full distance of 6000 miles, and its passenger, Minnie the mouse, survived a half-hour of weightlessness. Unfortunately, the nose cone couldn't be *recovered*, and Minnie died a watery death for her country. Much the same thing happened on July 23, when both nose cone and mouse sank in the south Atlantic. As comedian Bill Dana's "Jose Jimenez" character put it, "They closed the door...on that little mouse.... I don't want to talk about it!"

In those days Cape Canaveral was a remote Air Force reservation, nothing like the tourist trap it would become in later years. Dunn and his STL people stayed at the Tides Motel. It had louvered windows but no air conditioning, and lots of mosquitoes. "We were working ten, twelve, fourteen-hour days," recalls George Gleghorn. "There was precious little else to do in Cocoa Beach except sit on the beach."

The lunar satellite, the focus of the entire effort, was an 84-pound package designed and built at STL. Pioneer, as the spacecraft was called, had the shape of a toy top, and among its instruments was a line scanner, the most primitive type of TV camera. As the spacecraft rotated rapidly to stabilize itself, the camera would sweep a very narrow field of view across the sky, measuring the intensity of any light it saw. Successive scan lines would fit together to form a crude image. The hope was to use Pioneer to create the first map of the lunar far side, which no one had ever seen.

Finally, the day came for humanity's first attempt to shoot a rocket at the Moon: August 17, 1958. As members of the STL team watched, the Thor first stage ignited, lifted the rocket off the pad—then blew up 77 seconds into the flight, the victim of a failed turbo-pump. General Schriever was undismayed, saying, "We will go ahead just as fast as we can."

The next launch was set for October 11. Richard Booton, who ran the control center in Los Angeles, had his worldwide tracking network up and running. "We had ground stations at the Cape; Manchester, England; Singapore, and Hilo, Hawaii. We had a conference call involving Los Angeles and all those stations. We kept the line open for 36 hours. I've always wondered what the bill was."

In 1958, the launch of an unmanned rocket could stir journalists to near-rhapsody. A *Time* reporter saw the flight of Pioneer 1 this way:

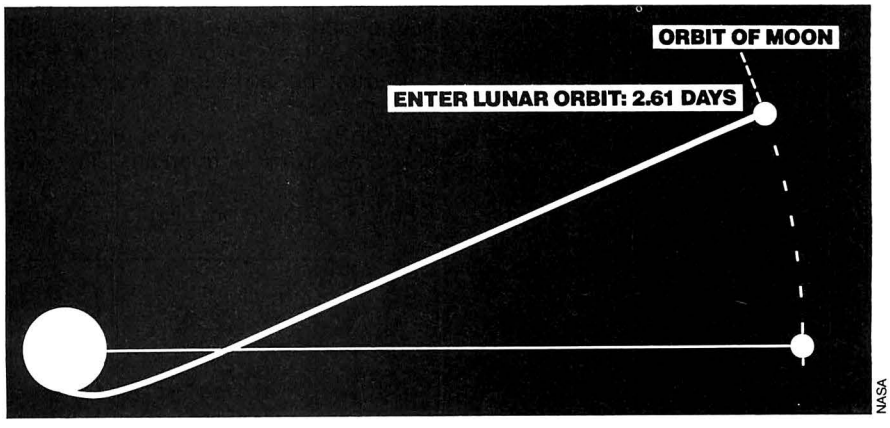
> Pad 17A at Cape Canaveral was bathed in a fluffy, gently swirling fog. Cradled in its candy-striped gantry, breathing icy puffs of liquid oxygen, was the Air Force's 88-foot Pioneer Moon-probe missile.... Just after zero, the blast burst down into the undulating swamp fog; there came a cloud of fiery gold that swept smoke and flame into eddying billows. As the rocket rose roaring, 100 newsmen cheered from the observation post a mile away, and down on the nearby beaches men, women and children, camped out in tents, told each other that this was a night to remember. Up into the black space shot Pioneer, trailing its dazzling fire.... In three minutes it was gone from sight, truly free, reaching up to where no man-made thing had ever touched. And a few moments later, as if responding to the challenge, the waning Moon rose out of the Atlantic.

Despite the fact that all three stages had fired, it very quickly became clear that this had not been enough. Booton, in the control center, had a separate phone line open to MIT's Millstone Hill radio telescope in Massachusetts, whose operators were reporting that the spacecraft's velocity was too low. "It probably wasn't more than five minutes into the flight before we knew we had a problem," he recalls. There were eight small steering rockets on the spacecraft, and with new data coming in from the Cape, the project leaders quickly decided to fire them all, hoping for an extra boost.

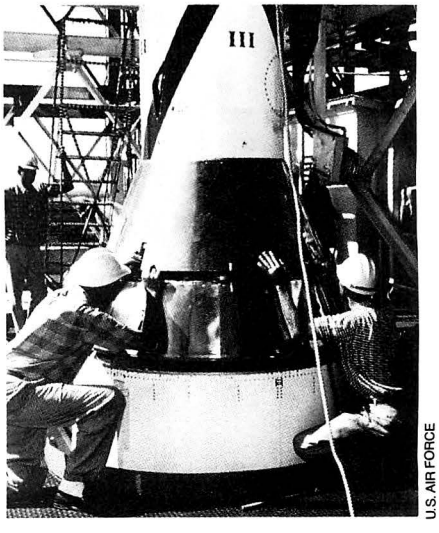
The satellite needed a speed of 24,000 miles per hour to reach the

continued on page 60

By October 1958, the trajectories had been calculated, the Thor-Able rocket (below, right) had been checked out, and the Pioneer probe (below, left) was ready for America's first Moon shot.



NASA



U.S. AIR FORCE

1968

SHOOTING THE MOON

Leaving Home

Twenty years ago this Christmas, Bill Anders made humanity's first great voyage outward

Before 1968, no person had ever seen the Earth in its true context—a small, lonely planet floating in the blackness of space. No one had sailed beyond the shallows of Earth orbit to travel somewhere else. But on December 21 of that turbulent year, three American astronauts fired the last stage of their Saturn rocket in Earth orbit and began history's first voyage to another world.

The Apollo 8 mission teamed Gemini veterans Frank Borman and Jim Lovell with Bill Anders, who was making his first (and only) spaceflight. On Christmas Eve, they fired their service module engine to brake into lunar orbit, where they stayed for 20 hours, circling the Moon ten times. Three days later they splashed down in the Pacific Ocean, having spent six days in a command module no larger than a family station wagon.

Bill Anders (right), Frank Borman (left) and Jim Lovell learned in August that their flight would orbit the Moon in December.

What I wanted to know, perhaps more than anything else, was what happens *after* you've been to the Moon. What do you do for an encore? Bill Anders didn't answer that question, because I never asked. By the time we finished talking, it was obvious: You don't stop. You keep working. As Anders understates it, "I've been busy in the past twenty years."

After he left NASA in 1969, Anders was appointed executive secretary of the National Aeronautics and Space Council, and later became the first chairman of the Nuclear Regulatory Commission. In the 1970s, he served briefly as the U.S. Ambassador to Norway. Today he's a senior vice president for a large aerospace firm in Providence, Rhode Island.

Like many astronauts, he has an air of easy confidence, and has a good sense of humor about his Apollo 8 crewmates and their mission. At 55, he looks athletic, and takes his sailboat out on weekends as often as he can.

In Anders' office we talked about Giovanni da Verrazzano, who first explored the coast around Providence in the 1520s, and about other great adventurers of the past. When I reminded him that this particular August day was the 20th anniversary of his crew's learning that their flight would go to the Moon, Anders seemed pleased. To tell the truth, he hadn't remembered. – *Tony Reichhardt*

Final Frontier: Are there particular moments when the memory of Apollo 8 comes back to you? Say, every time you see the full Moon?

Anders: It's not the full Moon. When we

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The dawn of a new age: "Earthrise" as viewed from Apollo 8.

went, the Moon was very new, so I can look at a full Moon and not even think about having been there. But every time I see the sliver of a new Moon, particularly when it's slivered to the right side, then I remember being out in the parking lot outside the crew training building down in Florida the night before the launch, sitting on the fender of a car with a friend of mine—my grad school physics professor—and his brother, looking up at the Moon and seeing that sliver.

Final Frontier: Is that crescent Moon what you remember from the flight?

Anders: On the way there, because the Sun was almost behind the Moon, we were told not to look at it, and the spacecraft was oriented so you really couldn't look at it. So we didn't see the Moon until we were in lunar orbit. I had sort of imagined it like being in an automobile driving up to the mountains, staring out the window, watching the Moon get bigger and bigger.

Actually we were going in rear-end first, getting ready for our retrograde [engine] burn to slow us down. We were in the shadow of the Moon and of the Earth. It was very dark. You could see stars everywhere except where the Moon was. It looked like we were falling into a big, black hole.

I've never had the hair stand up on the back of my neck, but just looking back there and realizing here was this body, like a freight train hurtling through space in the dark, and we were going to zip right in front of it and around, I thought, "I hope the navigation system works."

Final Frontier: Let's go back a few months before that. What was your reaction when they told you that your mission was going to orbit the Moon?

Anders: Well, I was very disappointed at first. I wanted to *land* on the Moon, because of the geology training and all of that. I had been teamed up with Neil Armstrong in Gemini, and we were probably going to fly on Gemini 13 if there had been one, but there wasn't one. That was a disappointment. Then he and I were either the first two, or very near the first two, to check out in the lunar landing trainer, which looked like a flying bedstead with an outhouse on it.

I got so I could fly it really well. So I thought, "You've got it made. Maybe you won't be first, but within the first five

you'll make it on the Moon." So I was really feeling good about that. I'd been assigned to the second lunar module, up at Grumman [Aerospace Corporation], to kind of shepherd it through its checkout. But the first one was having trouble. It bumped them all down on the schedule.

So NASA made the decision to switch Apollo 8, which was going to be an Earth-orbital checkout of the lunar module. They said, "Okay, we'll send them to the Moon, kind of Hansel and Gretel style—we'll lay out the bread crumbs and make sure the Russians don't pull a coup on us."

I don't think [NASA] really tried to make it at Christmas time, but they also

For some reason, I didn't expect the Moon to be as bombarded as it was. I mean, it looked like Verdun. It was just a mass of pockmarks.

didn't try to make it some *other* time—great PR possibilities there. And, taking your word for it, twenty years ago today, they let me know.

My first reaction was, "Hell, it's going to be great to be the first to go around the Moon, but I'd sure rather wait for a landing flight." That was a little shortsighted, but not totally. Because even today, given the choice between being the first around the Moon or being able to land on it, I'd opt for being even the last guy to land on it.

Final Frontier: I promise I won't ask whether you were scared or anything like that. But did it really dawn on you that you were about to *leave* the Earth?

Anders: I wasn't particularly scared. Look, we're all either test pilots or fighter pilots. I was flying up in Iceland. Flying in Iceland is more dangerous than going to the Moon, and certainly less dangerous in retrospect than Vietnam, where my colleagues were at that time. But I had thought about it. I mean, I just didn't leap into this thing. I had five children and a wife, no insurance to speak of. Nobody would insure us. I don't come from a wealthy background. If I didn't come back, the breadwinner wasn't there. But I thought it through, with my wife, and basically decided that certainly from an adventure point of view it was an unequalled opportunity. I was kind of an adventure buff as a kid. I used to like to read about Magellan's trip, and Lewis and Clark, and [John Wesley] Powell, and I thought, man, if I could just do that. So here was a chance to do that.

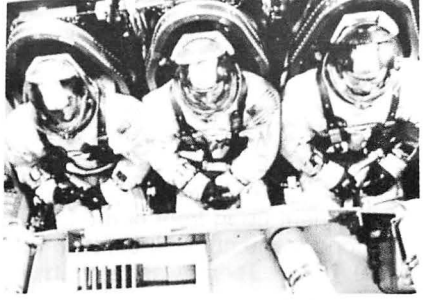
From the point of view of flying, it was the epitome. Regardless of what Yeager said about Spam in a can, this was one hell of a flight. So you couldn't...you had to think twice about turning that down.

Also, and this may sound a little corny, but we had the Vietnam war building up, we had unrest in the colleges, and America was kind of down and slack-jawed. Here was a nationally important thing that the country was behind. In the early '70s the bloom was off the rose for Apollo, but, boy, in that time people really *wanted* to do it. So just from a red, white and blue standpoint, it was important.

So if you add all that up, I had decided that if the risk of failure was no worse than one out of three, that I'd be willing to take my chances; or, more importantly, I'd be willing to expose my family to that chance. It's a dangerous business.

Final Frontier: I'm always impressed by the risks the Apollo program took twenty years ago. I'm not sure the space program can still take those risks.

Anders: I'm not sure. Maybe *in those* days it couldn't take it either, maybe if a Saturn 5 had blown up...remember, we were all test pilots, "mercenaries," if you will. It's one thing to kill a mercenary, but you kill one of the nation's very own school teachers from New Hampshire, and that's different.



Before their flight the crew trained extensively in a simulator that duplicated conditions in the tiny Apollo capsule.

Final Frontier: You were the first people to ride the new Saturn 5 rocket. What do you remember about that?

Anders: Well, we had gone through [simulations in] the launch abort trainer, and been shaken and thrown around and all that. But frankly, it was a little discouraging, because no sooner did we have ignition than things were different than the simulations. The lateral vibrations were much more violent. I mean they were *violent!* These big F-1 engines down there going ape trying to keep this thing straight up.

The noise was terrific. If anybody had yelled or screamed you couldn't have heard them for about the first ten seconds. So that was certainly different, and I thought, "Christ! If we're just off and it's that different, what's the rest of it going to be like?"

Then we got to the first stage [engine] cutoff. Now I was the official rookie on the flight, although I think on the Saturn 5 everybody was a rookie. And when the first stage cut off we were under about four and a half Gs, as I recollect. But then some small retrorockets fired on the first stage to start pulling it off, so you actually went from four and a half to slightly negative.

So the fluid in your ears did a complete slosh, and the net effect was that I felt like I was on one of these big old war catapults that the Romans used to have, you know, to heave boulders over the fort walls. I thought I was going right through that instrument panel! So I threw my hands up, and about the time

Anders (opposite page, onboard Apollo 8 during the mission), remembers the Moon as a stark, uninviting place.

I got them up in front of my face, the second stage cut in. It came in with a real bang. There was a fireball all around us. I thought, "What's happened here!?" (Laughs) My hand snapped back, and the wrist ring put a scratch in the face plate of my helmet.

Well, this little scratch, I kept looking at it and thinking, "As soon as the other guys see that, they'll know I'm a rookie." But when I looked over at them, they both had scratches, too. (Laughs)

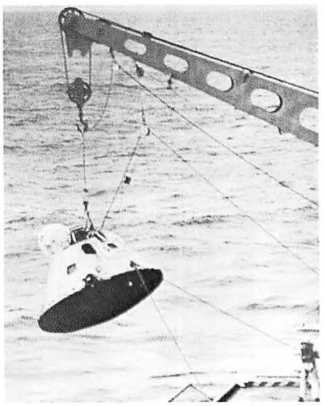
Final Frontier: Do you remember the first time you saw the Earth below you?

Anders: Some time during the launch, but I hardly saw the Earth at all. My job was to look at the instrument panel. Borman said, "Anders, if I catch you looking out the window, I'm going to fire you!" And he wasn't kidding. It wasn't until I was over India or somewhere that I thought, "I'm just going to peek out the side window." That was the first time I ever looked down in Earth orbit.

We were in Earth orbit for about one and a half revolutions or something like that, and I think I looked out three times. And I really hadn't the foggiest idea where I was, I was just so busy looking at all the gauges and checking things. Because this was the first time this beast was going to leave Earth orbit, and we wanted to make sure it worked.

Final Frontier: I think astronauts sometimes take a bad rap for not being more poetic at times like that. But you

Crew and spacecraft arrive safely on the deck of the *Yorktown*. Today the command module is on display at the Chicago Museum of Science and Technology.



Christmas 1968

It was an icy Connecticut evening in a house filled with noisy Christmas festivity. My host—a teacher of renown whom I greatly esteem—has a mind of generous curiosity and of eclectic concern, but is a man with a blind spot, at least at that time; he had found the space program a technocratic scam, overblown, financially extravagant, and basically a bore. As close as we always had been we rarely spoke of the astronauts and their flights. I had trouble that evening making him interrupt the party so that we could turn on the television set and follow the progress of the Apollo 8 module as it began its circuit around the Moon. Suddenly, there before us was that stark sphere, the craters, the jagged shadows that one knew to be chaotic mounds of rubble, the glistening white landscape projected against a backdrop of unfathomable darkness. The murmur and laughter of the party diminished and died, and we watched in silence while William Anders spoke the words from Genesis:

> In the beginning God created
> the Heaven and the Earth,
> And the Earth was without
> form, and void...

Ceremonial words tend to sound hollow and inappropriate, generally because they are predictable, touched by the stale hand of prearrangement. But these words, spoken at one of history's truly heroic ceremonials, seemed entirely appropriate, and I *remember* that a chill coursed down my back and an odd sigh went through the gathering like a tremor or a wind. Then how was it possible to be more deeply affected, to discover a pitch of eloquence more grand than those incantatory lines? Simple. Listen to Frank Borman, whose

STELLA JOHNSON

Twenty years later, it's the Earth that sticks in Anders' mind.

weren't passengers—you were making sure that the switches were set the right way so your engine fired properly.

Anders: Well, as interested as I've been in exploration and adventure and that kind of thing, it was clear to me personally, and certainly probably even more so to Frank Borman, who was the head of the mission, that if we busted our ass then all the poetic rhapsodizing in the world wouldn't offset that. So we basically disciplined ourselves not to get too carried away.

Now guys previous to us in the Mercury program came close to disaster. Scott Carpenter was ooh-ing and ahh-ing on the sunsets and overshot his mark and damn near killed himself. So we figured we'd better really keep our nose to the mission grindstone. Not that we wouldn't take a picture of the Earth-rise or note that the Earth was beautiful and the Moon was kind of stark. But we felt that our main job was to get there and back so that others could do the lunar science and the adventure aspect of it.

Final Frontier: Do you remember anything else about Earth orbit?

Anders: The one thing I guess I do remember was we were coming over Australia, and it must have been a hot, muggy summer day down there because there were a lot of thunderstorms—it was at dusk—and they were like giant light bulbs going off all over the place.

One of the things I missed on my flight was not having the opportunity, like they did in Skylab, to go round and round the Earth. Because, in retrospect, the Earth is really a lot prettier place than the Moon. The Moon is like a big battlefield, and after you've studied two or three meteor craters, they all look a lot alike. Maybe that's heresy to the geologists, but to me it looked like dirty beach sand where kids had been playing volleyball. That's what it looks like, and I said it over the radio [during the mission]. I got lots of nasty letters from the poets ever since. "Couldn't you come up with something more poetic?"

Final Frontier: When you look at the beach now, do you think of the Moon?

Anders: Oh, yeah. I went down to La Jolla about two months ago, stood on the sea wall and looked down and told the kids, "That's what it looks like." No papers and cigarette butts up there, but that's what it looks like.

Final Frontier: Were you able to watch the Earth recede as you headed toward the Moon?

Anders: I was looking out at the Earth,

continued on page 55

By William Styron

cheery valedictory brought home the reality, nearly lost in the sheer awesomeness of the occasion, that we were witnessing the exploit not of some crew of demigods or archangels but of mortally fleshed men like those of us gathered around a winter's fire: "Goodbye, good night. Merry Christmas. God bless all of you, all of you on the good Earth."

I glanced at my host, the mistrusting and scornful teacher, and saw on his face an emotion that was depthless and inexpressible. □

—William Styron is the author of Sophie's Choice *and* The Confessions of Nat Turner. *The above excerpt is from his essay in* The View From Space: American Astronaut Photography 1962-1972. *Reprinted by permission of Don Congdon Associates, Inc. Copyright 1988 William Styron.*

1988

SHOOTING THE MOON

THE SEARCH FOR A

Lunar Oasis

Of all the Moon's remaining mysteries, one stands out: Where's the water?

▼ ▼ ▼

BY PETER BAKER

The rules would be rather simple, if austere:

"Every Moonbase resident is granted a monthly water allowance, and may use that allotment of water in any way he or she chooses. Once the allotment is used, the individual will receive no more water until the first of the next month. Appeals can be made to the Water Allotment Board, but only cases of extreme need or system failures attributable to Moonbase itself are grounds for a successful appeal."

Moreover, for the crop of hardy colonists on the Moon, showers are virtually unheard of, except as a rare luxury usually reserved for the lunar elite. Instead, settlers "bathe" themselves with ultrasonic scrubbers that clean the body with vibrations.

That, at least, is the way writer Ben Bova envisions a 21st century lunar settlement without its own self-sufficient supply of water. The simple liquid that Earthbound humans so easily take for granted would be akin to gold or oil on a body that is so dry as to make the Sahara seem like a tropical rainforest.

But as America's space program gears up once again, many scientists are asking an intriguing question—what if Bova's assumption in his latest speculative book, *Welcome to Moonbase*, is wrong? What if there really *is* water on the Moon?

"Finding water at the [lunar] poles would be a gigantic change in the status quo," says Gregg Maryniak, chief executive officer of the Space Studies Institute think tank in Princeton, New Jersey. "It would be amazing. It would be the single biggest finding in the scientific community.

"It changes the universe."

That's not just idle talk. Although the Apollo missions to the Moon conclusively proved that not even the lunar rocks or soil—at least at the landing sites—contain even a trace of water the way their terrestrial cousins do, a corps of imaginative scientists and engineers still clings to the notion that water could really exist on the Earth's nearest neighbor.

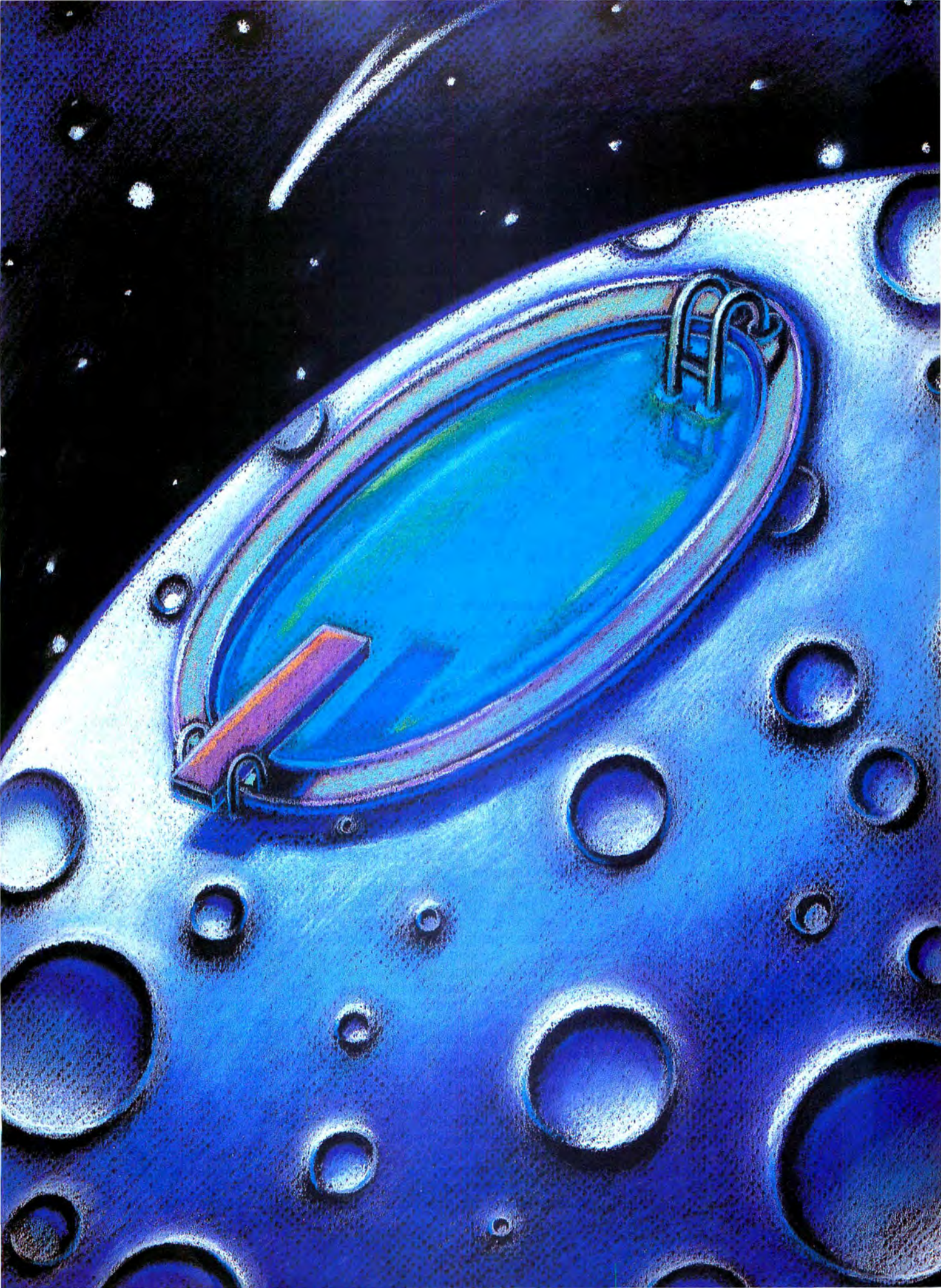
They postulate that water vapor deposited on the Moon by meteorites or comets could migrate across the globe and eventually settle in "cold-traps:" deep impact craters located strategically near the poles where they are in permanent shadow, and where temperatures remain low enough to weave a layer of ice.

Despite common misconceptions, the Apollo missions actually mapped out very little of the Moon, and missed the poles altogether. The polar regions are the only areas where such cold-traps could be located, because the Sun never passes overhead to warm the craters due to the Moon's negligible tilt on its axis.

"There are a lot of 'ifs'," acknowledges Michael Drake, a professor at the University of Arizona's Lunar and Planetary Laboratory. "The problem is, we don't have very good imagery of the Moon, and especially of the polar areas. My personal feeling is this is not a crank theory. If the circumstances are right, there should be water there. The question is whether these circumstances exist."

Although some theories on the subject surfaced as early as 1961, scientist James Arnold is generally credited with reviving the possibility of lunar water in 1979, with research based partly on Apollo data. Arnold, director of the California Space Institute, postu-

TRACY TURNER



lates that after water molecules are introduced to the Moon by comets or meteorites, they wander around in a "random walk" until something dramatic happens. About half the time, he figures, those water molecules will reach cold traps at the poles and settle there.

Although many scientists accept the premise, there are skeptics who challenge Arnold's conclusions.

In 1980, R. Richard Hodges at the University of Texas at Dallas presented research suggesting that Arnold's estimates were 25 times too optimistic. In Hodges' view, craters must be "double-shaded" in order to trap water—that is, a smaller crater must be set deep enough within a larger one to avoid not just sunlight, but reflected infrared rays as well. Arnold figures that as much as 0.5 percent of the lunar surface could be a cold trap; Hodges estimates a figure closer to 0.02 percent.

But, adds Hodges, "I have no doubt that there's water on the Moon."

Robert Staehle: "If I personally had $20 million to spend on the Moon—or I had somebody else's money to spend—this is the first thing I would spend it on."

▼ ▼ ▼

The overall cost might top $300 million for the ambitious project, which is supposed to produce the first complete global "inventory" map of the Moon—including land forms, gravitational and magnetic fields and surface chemistry. But even the price tag is not certain. According to Bevan French, program scientist for the mission at NASA headquarters in Washington, "'estimate' is too kind a word."

In light of the budgetary clampdown, there have been some preliminary discussions of a joint mission with Japan. The Japanese have been toying with the idea of a direct shot to the Moon that wouldn't include polar orbits, but would instead send "penetration" devices to implant in the lunar surface. French says his "wild-eyed wish" would be for the two nations to fly together and complement each other's work.

For their part, the Soviets appear to have shelved plans they had been discussing only a few years ago for a lunar mission, in favor of higher priority Mars projects.

The uncertain future of lunar exploration has raised the hackles of some in the scientific community who are impatient with political and bureaucratic delays and who want to get moving right now. Some are so irritated at the seemingly endless delays that they've begun to entertain the thought of a privately financed mission just to search for water.

"If I personally had $20 million to spend on the Moon—or I had somebody else's money to spend—this is the first thing I would spend it on," says Robert Staehle, president of the World Space Foundation and a leader behind the proposal. "It's the most important question to ask if you're interested in doing big and important things with the Moon."

Staehle says he is exploring the idea of a scouting mission with the Space Studies Institute in Princeton and the Planetary Society, and believes it could be done if the money could be found. The spacecraft, tentatively called Lunar Prospector Orbiter ("ELpro"), would conduct a stripped-to-the-bones mission with nothing fancy added, using hardware right off the shelf. With financial help on a launch vehicle, he estimates it would cost only $15 million to $20 million and could be in the sky in two years.

NASA's Jet Propulsion Laboratory in Pasadena, California has conceived of something called a "Quicksat" mission—a similar quick-and-dirty space shot that could be readied in two years. Although that concept officially remains in limbo, as long as there is the slightest chance of revival, Staehle says he will hold off on his proposed private venture in deference to the government.

As far as Jim Arnold is concerned, it doesn't really matter who does it or how. He just wants someone to return to the Moon and settle the question once and for all—and quickly.

"I've posed a good scientific question and I damn well want an answer," says the 65-year-old scientist. "I'm very frustrated. Some of my friends and I started working on this soon after Apollo, and now we're getting ready to celebrate the 20th anniversary *next* year. You only live so long. I want them to get this done before I'm gone." □

Peter Baker is a reporter for The Washington Times. *His articles also have appeared in* The Chicago Tribune *and* Insight *magazine.*

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FRONT BACK

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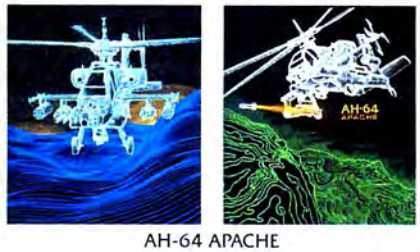
F-15 EAGLE

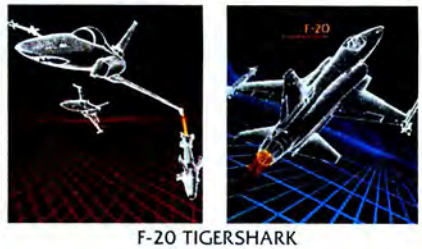
FRONT BACK

F-16 TACTICAL FIGHTER

B-1B STRATEGIC BOMBER



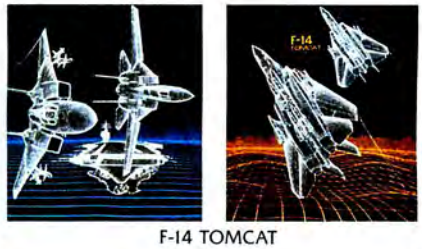
AH-64 APACHE



F-20 TIGERSHARK

F-18 HORNET

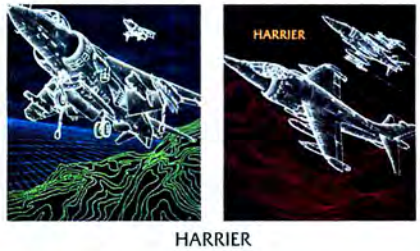
F-4 TACTICAL FIGHTER/BOMBER



F-14 TOMCAT

NEW

A-10 THUNDERBOLT



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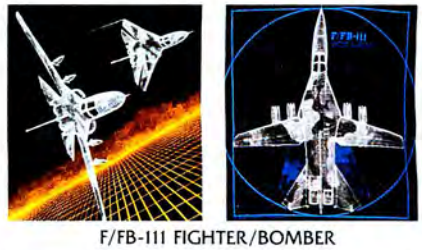


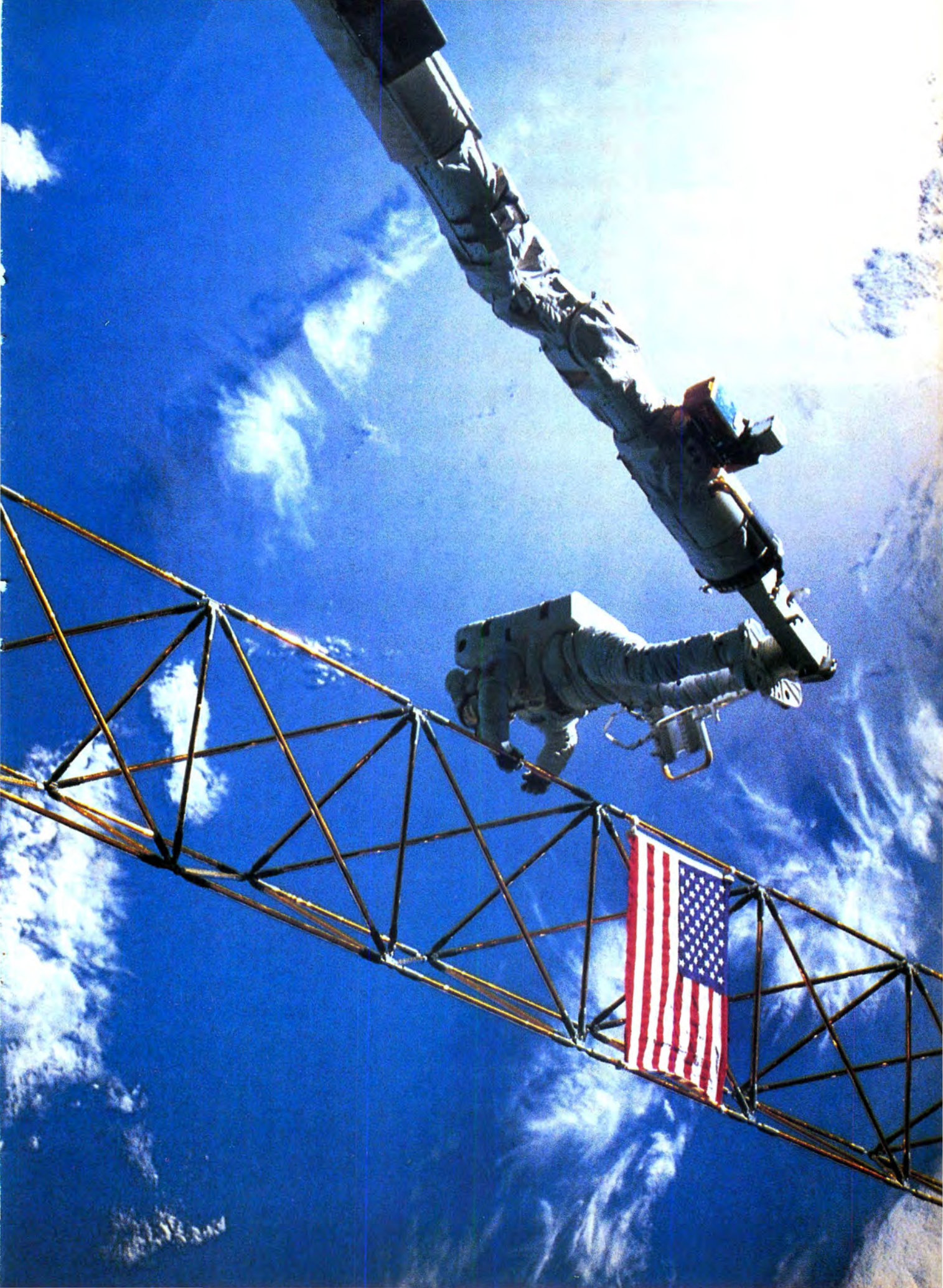
F/FB-111 FIGHTER/BOMBER

KC-135 STRATOTANKER

(actual shirt photos)

C-130 HERCULES

C-141 STARLIFTER



MISSION FILE STS-26

"We Have Resumed the Journey"

It felt good to be back.

For NASA, it marked the end of a 32 month-long exorcism that began in a single, horrifying moment in January 1986. The 26th flight of the nation's Space Transportation System was about forgetting that moment, and about getting on with the future. It proved that the long and difficult post-Challenger recovery program, with a price tag estimated at anywhere from $2.4 to $3.5 billion, had been worth it. As one smiling agency official said at a press conference following Discovery's triumphant launch, "We've had cabin fever, and now...we're back out on the trail again."

For the public, it was a chance to put those same ghostly TV images of the shuttle launch that leads inevitably to disaster out of the collective mind. This time there was no tragedy, no confusion. The astronauts reached orbit as expected, launched a NASA relay satellite and conducted experiments as expected, fooled around in zero-gravity and spoke to a nationwide TV audience as expected, and then landed safely at Edwards Air Force Base in California, all according to the book.


NASA

But it was the launch itself that represented the greatest psychological hurdle. Some 250,000 spectators lined the roadways and the beaches surrounding Florida's Kennedy Space Center to witness the shuttle's dramatic return to flight. On launch pad 39B, Discovery's crew of five veteran astronauts awaited their "go" for liftoff, originally scheduled for 9:59 A.M.

Unexpectedly light winds over the launch site forced officials to delay the liftoff, as the computers that controlled Discovery's trajectory had been programmed to expect stronger winds at high altitudes. But when launch managers decided that the wind factor did not pose a real risk, the countdown clock was re-started.

And for the first time in nearly three years, at 11:37 A.M. on September 29, the world watched a space shuttle rise off the launch pad and into space.

Day 1

With the successful ascent to orbit under their belts, Discovery's crew turned immediately to the main purpose of their mission: the launching of NASA's third Tracking and Data Relay Satellite (TDRS). The shuttle delivered the first of these satellites into orbit on its sixth flight in 1983, but since then NASA has been frustrated in its attempts to get the full system up and working. The second TDRS was lost in the Challenger explosion in 1986.

In its final configuration, the TDRS system has two relay satellites stationed over the Atlantic and Pacific oceans, at an altitude of 22,300 miles. The shuttle can use the satellites to transmit or receive television signals, data and voice communications. Thanks to TDRS, the shuttle

is in nearly constant communication with Mission Control, instead of having to wait until it passes within range of ground antennas. The relay satellites also can handle high rates of data from spacecraft like the Hubble Space Telescope, due for launch in 1990.

At just over six hours into the flight, astronaut Mike Lounge sent the command to spring the TDRS and its attached Inertial Upper Stage (IUS) booster out of the orbiter's cargo bay. In spectacular TV images later transmitted to the ground, the 5000-pound satellite floated serenely over Discovery's crew cabin and moved slowly away against the backdrop of the cloud-dappled Pacific Ocean south of Hawaii. An hour later–after the orbiter had maneuvered to a safe distance and orientation–the attached booster fired to start TDRS on its long journey up to geostationary orbit.

After TDRS-3 (as the satellite was renamed once it reached orbit) was safely deployed, mission specialist "Pinky" Nelson turned his attention to activating four of the secondary experiments mounted in the shuttle's mid-deck area. Nine hours into the flight, the astronauts had converted Discovery's mid- deck area into a microgravity laboratory in space.

Two minor problems that had cropped up earlier in the day continued to nag at the astronauts. A backup controller on one of Discovery's maneuvering engines had failed before liftoff, and efforts to activate it were unsuccessful. More serious was a buildup of ice in the evaporator system that cools the orbiter's equipment during launch and reentry. Temperatures in the cabin soared into the high eighties before leveling off near eighty degrees. The astronauts did what anyone accustomed to living in Houston would do–they put on shorts and stayed in the downstairs mid-deck, where it was cooler.

TOM USCIAK

"Out on the trail again": Hauck, Covey, Lounge, Hilmers and Nelson head for the launch pad.

Day 2

"Goooooooooooood Morning, Discovery! Rise and shine, boys. Time to start doing that shuttle shuffle...."

Discovery's astronauts were awakened from their sleep by a taped greeting from comedian Robin Williams, followed by a spacey variation on the "Green Acres" theme produced by a local radio station in Houston. The crew settled into their on-orbit routine, working with mid-deck scientific experiments and performing medical tests designed to evaluate the human body's response to weightlessness.

Televised scenes sent back to Earth showed "Pinky" Nelson using an optical device that may help space travelers to pre-adapt their physiological balance sensors to the confusing world of zero-gravity. Meanwhile, Mike Lounge aimed cameras at Mexico's Yucatan peninsula, attempting to photograph evidence of earlier damage caused by Hurricane Gilbert.

The day's only real disappointment was the failure of the pointing mechanism that controls an onboard antenna used for television and for high data rate communications. The antenna, which operates in the Ku-band of the radio spectrum, began to wobble back and forth, making it impossible to lock on a signal. Mission Control in Houston subsequently sent Discovery's crew a multi-step procedure to stow the antenna and its supporting arm in the orbiter's cargo bay.

The only significant effect of the malfunction was on the crew's ability to transmit TV pictures of their activities. For the remainder of the mission, television was restricted to those times when Discovery was within range of tracking stations in Hawaii, California and Florida–a good case-in-point demonstration of the value of using the TDRS satellite.

Day 3

Discovery's crew continued to swelter in the mid-80s, but their discomfort seemed minor on what was otherwise proving to be a marvelously routine flight. The astronauts' scheduled "timeline" of activities had included time for troubleshooting problems that NASA planners had expected on this first flight of the modified shuttle orbiter. When those problems failed to turn up, the crew had plenty of free time on their hands, since many of the mid-deck experiments were running automatically.

During their meal, the astronauts alternately joked with ground crews and congratulated them for a job well done (at one point holding a flight patch emblazoned with the words "Mission Control" in front of the cameras). Commander Hauck also showed off for his TV audience a peanut butter and jelly tortilla he had prepared for lunch.

The astronauts' most important activity was a rehearsal of preparations for reentry, including practicing the use of a new emergency escape system and the donning of new partial-pressure flight suits, which the crew also had worn during launch as a safety measure. "This is probably not a one-man operation," radioed Mike

Lounge as Hauck and Nelson sweated and struggled their way into the bulky garments. Hauck found that it was impossible to force himself into his seat on the orbiter's flight deck without assistance from pilot Dick Covey.

Nelson also conducted an experiment using a device that uses infrared waves—much like a television remote control—to transmit voice communications within Discovery's cabin. Nelson tried transmitting his voice through wall-mounted receivers and transmitters while moving around the cabin. The test, which was successful, may enable engineers to do away with the cumbersome wires that now link the astronauts' headsets with their control panels. Infrared waves also do not penetrate the orbiter's windows, meaning that radio receivers outside the shuttle would not be able to eavesdrop on astronaut conversations during secret military flights.

The scientific experiments in the mid-deck area continued to function smoothly. Most ran automatically, with the crew occasionally monitoring their progress or taking photographs. Nelson reported that "lots and lots" of crystals were growing in a Protein Crystal Growth experiment, which aimed to produce large, pure crystals that can be used in research directed at understanding diseases such as cancer and AIDS. Several other material processing experiments also produced samples in microgravity that will be studied by researchers on the ground.

The Mesoscale Lightning Experiment, which used cameras in the orbiter's cargo bay to photograph nighttime lightning discharges from storms in the Earth's atmosphere, was the only disappointment among the scientific studies. The problem, though, was beyond the crew's control—there simply weren't many storms occurring beneath Discovery's path around the globe. The crew also photographed the eruption of Indonesian volcanoes, Egypt's Lake Nasser, forest preserves in India and other items of interest as the Earth's surface passed underneath them.

Day 4

It was a day to celebrate Discovery's—and NASA's—success, but the astronauts also took time to remember the seven trailblazers who died in the Challenger accident in 1986.

"Dear friends, we have resumed the journey that we promised to continue for you," Rick Hauck said solemnly during an emotional press conference televised on Sunday afternoon. "Your spirit and your dream are still alive in our hearts."

The crew also took questions from reporters at Houston's Johnson Space Center. Mike Lounge voiced his hope that the enthusiasm for Discovery's flight carries over to the "dozens and dozens of missions" that NASA has planned for the next decade. And pilot Dick Covey succinctly summed up the reason for continuing the shuttle program: "There are new adventures everywhere, and space is one of them."

By the evening of their fourth day in space, the astronauts had successfully wrapped up most of the mission's scientific objectives. They deactivated the Aggregation of Red Blood Cells experiment—designed to measure the formation rate and structure of red cell clumps in zero-g—the Isoelectric Focusing Experiment (a device to separate proteins in an electrical field) and the Protein Crystal Growth experiment.

Day 5

Shortly after waking to an ersatz Beach Boys tune ("We'll have fun, fun, fun, 'til it's time to put the shuttle away...."), Discovery's crew began to button up their ship for the ride home. The astronauts shut down the remaining mid-deck experiments, then started the laborious process of "suiting up" for re-entry in their orange-colored pressure garments.

As Discovery sailed over the Indian Ocean, its maneuvering rockets fired to bring the orbiter and its crew back to Earth. Thirty-three minutes later, the astronauts entered a radio communications blackout caused by the 100-ton spaceliner's searing re-entry through the

LAUNCH: 11:37 A.M. EDT, September 29, 1988
Pad 39B, Kennedy Space Center, Florida

LANDING: 12:37 P.M. EDT, October 3, 1988
Edwards Air Force Base, California

ORBITER: Discovery

ALTITUDE: 160 nautical miles

CREW: Rick Hauck, Commander
Dick Covey, Pilot
Mike Lounge, Dave Hilmers, George "Pinky") Nelson, Mission Specialists

PRIMARY PAYLOAD:
NASA's third Tracking and Data Relay Satellite (TDRS-C)

SCIENTIFIC EXPERIMENTS:
Physical Vapor Transport of Organic Solids
Automatic Directional Solidification Furnace
Aggregation of Red Blood Cells
Isoelectric Focusing Experiment
Mesoscale Lightning Experiment
Phase Partitioning Experiment
Earth Limb Radiance Experiment
Protein Crystal Growth Experiment
Infrared Communications Flight Experiment
Two Shuttle Student Involvement experiments
OASIS-1 (environmental measurements of orbiter's cargo bay)

UPI

For the first time in years we saw an American TV show from space.

atmosphere. When contact was re- established, commander Hauck reported that he had the California coast in sight.

A double sonic boom brought cheers from 425,000 spectators gathered in the Mojave Desert as Discovery dropped below the speed of sound over its Edwards Air Force Base landing site. With Hauck and Dick Covey manually flying the orbiter, the spaceship-turned-airplane began a long, graceful turn to line up with the runway laid out on the dry lake bed.

Seconds before touchdown, Hauck lowered the spaceplane's wheels and deftly brought the craft down to a perfect landing. As Discovery rolled to a stop, Blaine Hammond – the astronaut "capsule communicator" at Mission Control – radioed the STS-26 crew a message that neatly summed up their accomplishment.

"Welcome back," exulted Hammond. "A great ending to the new beginning!"

On the Launch Pad

Shuttle mission *STS-27*, slated for liftoff on November 17, will feature Atlantis hauling a classified military payload into orbit. As part of its agreement with the Department of Defense, NASA withholds details such as orbital altitude, mission duration and the nature of any secondary experiments. Even liftoff and landing times are normally kept secret until a few hours prior to the event.

The names of the astronauts for mission 27 *have* been released. Robert "Hoot") Gibson will command his second shuttle mission, with space rookie Guy Gardner as pilot. Mission specialists Mike Mullane and Jerry Ross – both shuttle veterans – and Bill Shepherd round out the crew.

This will be the third flight for Atlantis. The orbiter's inaugural voyage, a four-day classified mission, took place in October 1985. Atlantis last flew from November 26 to December 3,1985; three commercial communications satellites were launched, and astronauts Jerry Ross and Woody Spring practiced space construction techniques.

Discovery will return to space early next year on *STS-29**, a five-day flight currently scheduled to lift off on February 18. Shuttle commander Michael Coats and mission specialist Jim Buchli are space veterans; pilot John Blaha, Bob Springer and Jim Bagian will make the trek into orbit for the first time.

Just as on STS-26, Discovery's primary payload will be a Tracking and Data Relay Satellite (TDRS). NASA plans the new TDRS as a replacement for the original satellite in the series, which has suffered degraded performance since its launch in 1983. A fully functional TDRS system will have two working satellites – TDRS-East and TDRS-West – as well as an on-orbit spare in case one of the other two should malfunction.

STS-29 also features an interesting mix of other objectives. Two more student experiments are on tap, along with another Protein Crystal Growth experiment. SHARE will test the performance of a radiator being evaluated for use on the space station Freedom, and SSBUV, an ultraviolet scientific payload, will measure ozone in the atmosphere. Discovery's astronauts also will carry a wide-screen IMAX movie camera to record the mission's activities.

The flight will mark Discovery's eighth trip into space, making it the workhorse among NASA's three operational spaceliners.

*Actually the *28th* shuttle flight; STS-28, a military mission, is now scheduled for July 1989 – *after* STS-30. NASA keeps the original number designation of a shuttle flight even if it slips in the schedule.

NASA

"A great ending to the new beginning": Discovery touches down at Edwards.

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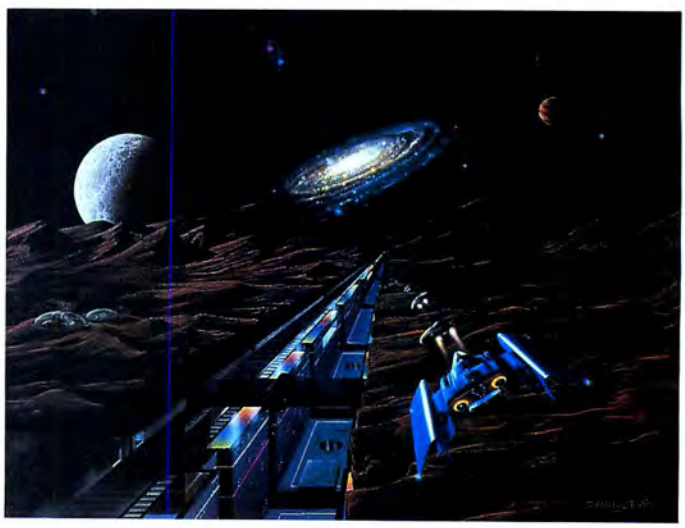

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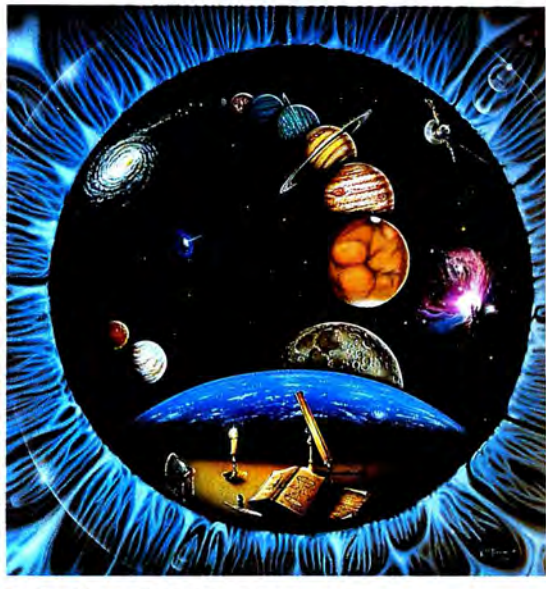

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Thousands answered NASA's call that year, but only a few— T.J. Hart among them–were chosen.

How I Became an Astronaut

BY TERRY J. HART

It was one of those winter evenings that made you want to spend the rest of your days beside the fireplace sipping coffee and reading your favorite weekly. My two years of marriage had left me content to live a comfortable life with my budding young family in the countryside. Our home was surrounded by dairy farms, and the half hour drive to work at Bell Telephone Laboratories was a scenic tour through the rolling hills of northern New Jersey.

Four years of academics at Lehigh, a year at MIT and two years of night school at Rutgers had led me to an enjoyable and rewarding career as a design engineer. A four-year tour flying fighters in the Air Force, besides being more fun than anyone should be allowed to have, had provided me with a second career as a weekend warrior in the New Jersey Air National Guard's F-106 interceptor squadron in Atlantic City. I considered myself most fortunate.

So it was more with curiosity than with serious attention that I read an announcement in a National Guard magazine describing NASA's plan to hire about 40 astronaut candidates to train for space shuttle missions. Anyone with an appropriate flying or technical background who was in reasonably good health was cordially invited to apply before April 1, 1977.

As a wide-eyed 11 year-old, I had marveled at the sight of Sputnik flashing across the early evening skies of my Pittsburgh home. Although I would daydream at times about the adventure of spaceflight, I had never thought of the space program as a career opportunity, let alone as a chance to fly in space myself.

But the thought of applying tantalized me. I convinced my wife, Wendy, as well as myself, that there was no chance I would be selected. It would be interesting, though, to see just how far into the selection process I could go before being eliminated. Anyway, I can always turn them down if I'm selected. Right?

So with all my rationalization in good order, I began to fill out the application form–essentially my whole life story in triplicate–which I've always believed is NASA's first measure of a candidate's determination. The interviews and the medical testing were to take place over the summer and fall of 1977, with the selection to be announced around the first of the year. The reporting date for the lucky 40 would be in July 1978. After mailing my application (several weeks before the deadline), there was nothing to do but wait.

The first sign that I was in the running came when several of my friends were

NASA

Seven years after turning in his astronaut application, Hart finally reached orbit on the eleventh shuttle flight in April 1984.

visited by G-men asking strange questions. Some were unaware that I had applied, and one neighbor was convinced that I was either evading taxes or involved in a drug smuggling operation. Soon after the door-to-door interviews, my references started getting phone calls from members of the NASA selection board.

As encouraging as that was, time was running out. It was October, and the screening had been underway since early in the summer. Finally, the telegram came inviting me to a week of evaluation at NASA's Johnson Space Center in Houston. Now the competitive juices began to flow.

As it turned out, I was in the ninth of ten groups to be evaluated. Each group numbered about 20 and generally had applicants of similar backgrounds: test pilots in one group, geologists in another, and so forth. Our group was more varied. Most of us were scientists and engineers, and were being interviewed as "Mission Specialist" candidates. In the shuttle era, Pilot Astronauts would fly the spacecraft, while the newly defined Mission Specialists would be more involved with the actual payloads.

I think even NASA was surprised at the number of qualified applicants who answered their call: about 1500 pilots and 6500 mission specialists! Many, like myself, had qualified and applied for both positions.

So there I was with 19 other overachievers in a Sheraton Inn conference room on a Sunday evening in November 1977, listening to some guy with a Georgia accent describe the shuttle program. The speaker apparently needed no introduction, for none was offered. John Young, then chief of the astronaut office, briefed us on NASA's plans to fly 500 missions with five space shuttles in ten years. He and Bob Crippen were training to fly the first mission, which at that time was scheduled for March 1979.

As for our part in all this, we were told that only 30 or 40 slots were currently open, so most of us would not be selected. Those who were could expect two years of training and evaluation, *after* which they would become eligible for assignment as a crew member.

As I tried to sleep that night, I was caught up in the magnitude of the program for which I was applying, and for once in my life I wondered if I might not be getting in over my head. The testing began Monday morning, and any thoughts of self-doubt were quickly forgotten as I joined in the spirit of the competition.

Most of the week was dedicated to the doctors of the Flight Medicine Clinic, whose job it was to seek out medical "anomalies" and recommend the elimination of anyone who fell out of standards for any one of a large number of tests.

Unfortunately, some of my data points appeared to be doing just that! Monday evening, several of us were told to fast on the following morning because we would have to repeat some of the blood tests. Not to worry, repeats are often necessary because of lab errors and that sort of thing.

When I was told the same thing on Tuesday night, I started to worry. It seemed my uric acid was a little high. So what's uric acid and what does it have to do with flying spacecraft? It causes gout and kidney stones—not exactly a serious problem, and easily controlled by dieting. But as far as NASA was concerned, hyperuricemia was disqualifying.

At least they were good enough to give me a printed list of foods to avoid—brown gravy, wine, asparagus, avocados and artichokes. Since I had never done much damage to the asparagus, avocado and artichoke populations of the world, I figured it must have been the gravy and wine. Actually, I was told, it was probably just the natural balance of my system. In other words, they were trying to be sympathetic about disqualifying me.

The most significant event of the week was the interview with the selection board. Chaired by George Abbey, the Director of Flight Operations, and made up of several astronauts and officials of the Johnson Space Center, this board made the ultimate selection—with the approval, of course, of NASA Headquarters in Washington.

Each of us was asked to prepare a one-page essay on our reasons for wanting to become an astronaut. I suspect that most of the candidates played it pretty straight and composed an appropriately dignified response similar to mine:

> Man's outstanding virtue is his thirst for knowledge. Coupled with a motivation to improve his life, it has created a vast technology which serves all men. As an engineer I have dedicated my professional life to the advancement of technology, and I derive a great deal of satisfaction from being a part of it. The opportunity to work as an astronaut represents to me a chance to extend my technical contributions and job satisfaction by being responsible for the ultimate implementation of state-of-the-art technology in space.

Heavy! I felt like Miss America responding to a question from Bert Parks. Rumor had it that the all-time winner was Jon McBride, Navy fighter pilot and bon vivant, who said he wanted to become an astronaut because West Virginia, his home state, needed a hero. Another applicant offered, "Because my father was an astronaut, and my grandfather was an astronaut, and my great-grandfather..."

I don't know how my rather stuffy passage compared to the others, but as I sat in the waiting room of the trailer set up for the selection board, I could hear chuckling as the members finished their lunches. Of course I assumed they were laughing at *my* essay. Oh well, since I almost certainly had been eliminated already by my artichoke-laden blood, I tried to relax and soak up the experience.

I suspect that my relatively laid-back attitude worked to my advantage during the interview. The board members were cordial, even friendly, and seemed genuinely interested in what I had done and what I thought about a variety of subjects other than the space program. It was not the formal atmosphere of a typical job interview, but a rather free-wheeling discussion that ranged from the techniques of landing a flamed-out F-106 to Ayn Rand's *Atlas Shrugged*. Once again my impression was that this government agency was a first-class operation.

For me, the highlight of the week was the Wednesday night social. This was a dinner gathering of the applicants, members of the board, and other astronauts who were there presumably to tell us what the job was *really* like.

The evening revolved around tales of flying in aircraft and spacecraft. I spent most of it listening to Jack Lousma describe the wonders of life aboard Skylab. When the talk came around to the shuttle, I could see the excitement with which the veteran astronauts looked forward to this wondrous machine that would give them more frequent flights than they had ever imagined during the earlier programs.

After the meal several of the selection board members stood up and gave a tongue-in-cheek synopsis of how our group of applicants was shaping up. Obviously we were the smartest and best-looking group they had seen so far, but unfortunately, since we had arrived so late, there was only one slot left unfilled—and that was reserved for one of the board members.

In case we were wondering what they'd done with the gallons of blood

and urine we'd given for our country, they explained how it had all been mixed together and shipped to Cape Canaveral. This was our real contribution to the program—a new rocket fuel additive. They'd obviously had a great deal of fun doing this kind of roasting every other Wednesday night for the last four or five months.

The next morning brought more bad news from my friendly flight surgeon. My third blood sample, tested in another laboratory, showed the same excess of uric acid. I commiserated with Judy Resnik, who'd been undergoing the same repeated blood tests for some other obscure anomaly. We concluded that it had certainly been a worthwhile experience, even though we apparently were out of the running.

Meanwhile, the psychiatric exams turned out to be much less rigorous than I had expected. At least I think they were! The first of two one-hour sessions took place in the doctor's office, with a scenic view of the trees and ponds of the space center's central quadrangle.

The psychiatrist asked questions in a very formal manner from behind his desk, made notes on his clipboard and almost never made eye contact with me. The questions seemed to be designed to test the brain's circuit paths: counting backward from 100 by sevens, doing decimal division in your head, reciting a sequence of numbers forward then backward, and so forth. It was my impression that the shrink was really looking to see how I would react to my inevitable failure to repeat an ever-longer sequence. I decided that guessing would be bad form, and capitulated at nine numbers forward and seven backward.

The second hour was quite different. I found myself in a sterile room devoid of any windows or decorations. The only furnishings were two opposing chairs. This psychiatrist was more amiable than his predecessor, and his questions were of a much more personal nature.

Along with the typical "Did you beat your parents?" questions were winners like "What kind of animal would you want to be in your next life?" None of us had any idea of the relative importance of these exams, but they made for lively entertainment in the evenings as we compared notes over a couple of beers.

There was one unrelated test that I considered to be more of a psychological exam than either of the others. The proposed method of crew rescue in the event of a shuttle becoming stranded in space was to transfer each individual inside a small, inflated sphere to a rescuing shuttle. The sphere would be about three feet in diameter, opaque, and would keep its occupant alive using the life support system of a rescuing astronaut, who would space walk between the two ships. A clever idea, even though the shuttle's launch rate wouldn't support the concept of a rescue mission for many years.

As silly as it seemed to those of us who took a ten-minute nap inside the balloon, it was undoubtedly wise of NASA to have each of us try it out. It would be more than a little embarrassing if national television recorded the shuttle's hatch flying open on the launch pad as a wild-eyed, claustrophobic crewman decided to beat feet.

As the week drew to a close, I felt that I had done my best in each of the tests, and that I'd been myself during the interview. The results of my blood tests still hung over my head, but the selection board hadn't yet formally eliminated me. On the other hand, maybe a medical disqualification would be more palatable than simply not being selected. I could at least think that I might have been chosen if I

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hadn't eaten so many artichokes.

The announcement of the selection was to be made in mid-December. Back home in New Jersey, I was removed from any of the scuttlebutt that typically pervades military organizations when there is an impending announcement. Any thoughts about turning NASA down had been put aside long ago—I ardently wanted it, and I was braced for the disappointment. But Christmas came and went without any word.

On January 16, as I was driving to work, I heard on the radio that the selection had been made. It included 15 Pilots and 20 Mission Specialists, six of whom were women. My heart sank—that left only fourteen slots, surely not enough for me to be included. I waited for my phone to ring with the bad news.

At 7:30 the secretary at the other end asked me to hold for Mr. Abbey. In the 15 seconds that followed I took several deep breaths and tried to get my pulse below 200 so I might be able to utter an intelligible response to the verdict. It didn't work. George, never given to using three words when one would do, allowed as how he would like me to start work in July if I was interested. I mumbled some kind of an affirmation that must have been adequate, since I found myself talking to a personnel officer about salary and other details that totally escaped me.

I was not prepared for the attention that I received in the days that followed. Astronauts have typically been hired from military or aerospace communities, and here I was, an astronaut selectee in the middle of New Jersey, working for good old Ma Bell.

The most difficult aspect of the sudden attention was that everyone expected me to be an instant expert on the space program. It was all too easy to fall into the trap of speaking as though I knew something about space, which of course I didn't. I figured it would be far less embarrassing to the agency if I didn't try to be a spokesman quite yet.

As we gathered our growing family (Wendy had just found out she was pregnant with our second child) and began the trek to Houston, I reflected upon the curious twists that my career had taken over the years: Bell Labs, the Air Force, the New Jersey Air Guard, night school at Rutgers. It was clear to me that my selection as an Astronaut Candidate had hinged on each of these experiences and on the support of my friends and colleagues. I felt lucky to be a part of the adventure that was about to begin.

And I was determined to succeed in it. □

A NASA astronaut from 1978 to 1984, Terry Hart flew on the eleventh flight of the space shuttle in April 1984. Now a technical manager for Bell Laboratories, he is writing a book about his astronaut days, from which this article is adapted.

What do you mean you forgot the TANG?

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SPACE

Our musical salute to the Space Age

It was a marriage made in the heavens. • After all, rock'n'roll and space travel grew up at the same time. Is it any coincidence that MTV's first logo was an astronaut standing on the Moon? Or that ZZ Top applied to NASA to be the official "lounge group" when the space shuttle begins carrying passengers? • Once we started digging, we un-earthed a whole stack of songs written about space in the past thirty (or so) years. We started with the obvious ones, like "Telstar" and Elton John's "Rocket Man." Then we turned to the folks at the Music Library and Sound Recordings Archives at Bowling Green State University in Ohio, and to writer Bill Carswell of Huntsville, Alabama, who had compiled an impressive list of his own. • In our quest for spacesongs, we found ditties about rockets, and astronauts, and space love, and even intergalactic laxatives. And that's not counting all the music that's been played *in* space, like the tape prepared for the Apollo 14 astronauts by Jerry Lee Lewis, or the recording of the Pyanitsky Choir used to test radio-communications from the Vostok spacecraft before Yuri Gagarin's first flight in 1961. • We included songs about UFOs, but left out approximately twelve billion Moon songs, among them "Blue Moon," "Mr. Moonlight," "If You Stub Your Toe on the Moon" and "The Cop on the Beat, The Man in the Moon and Me." In some cases we may have stretched our criteria just a bit. Sue us. • Or better yet, write us. This *can't* be all the space-related tunes out there, so we're counting on you to pick up where we've left off. Whoever sends us the longest list of bona fide (that means recorded or published) spacesongs that *didn't* make our list, before January 31, wins a free year's subscription or renewal, along with a FINAL FRONTIER T-shirt personally autographed by Elvis (if he ever shows up again). • So turn up the jukebox, put on your dancing shoes, and let the Moonwalking begin.

Armstrong/John Stewart
Armstrong, Aldrin, & Collins/The Byrds
Around the Universe in Eighty Days/Klaatu
Arriving UFO/Yes
Astral Traveler/Yes
Astro Boy/The Buggles
Astro Man/Jimi Hendrix
Astronaut Food/Sopwith Camel
The Ballad of John Glenn/Roy West
Beyond the Universe/Rick Derringer
Black Hole Star/The Neutrons
Blast Off/Tyrone and the Tyrone Trio
Calling Occupants of Interplanetary Craft/The Carpenters
Children of the Moon/Alan Parsons Project
Children of the Universe/Comus
Countdown/Dave Brubeck Quartet
Countdown/Manfred Mann's Earth Band
Countdown/Rush
Cybernaut/Tonto's Expanding Head Band
Cygnus X-1/Rush
Dark Side of the Moon/Nichelle Nichols
Destination Moon (Album)/The Ames Brothers
Earth Girls are Easy/Julie Brown
Earthling/Jobriath
Echoes/Pink Floyd
Edge of the Universe/Bee Gees
ETI (Extraterrestrial Intelligence)/Blue Oyster Cult
Fly Away/Jefferson Starship
Fly on UFO/Chromium
Flying Saucers Rock'N'Roll/Billy Lee Riley
4th Dimension/Devo
Fred from Jupiter/Digitte
Galaxy/War
Gravity/Ricki Lee Jones
Guided Missile/The Cufflinks
Have You Seen the Saucers?/Jefferson Starship
Humanoid Boogie/Bonzo Dog Band
I Am the Eagle/John Denver
I Want to See Another World/Jefferson Starship
The In Sound From Way Out (Album)/Perry and Kingsley
In Search of Space/Hawkwind
Intergalactic Love Mission/Rox Frenzy
Intergalactic Laxative/Donovan
Intergalactic Love Song/Charles Earland

SONGS

Intergalactic Trot/Robert Mason
Interlude 2001/Spirit
Interplanetary Travelers/Sonny Simmons
Interstellar Overdrive/Pink Floyd
I've Seen the Saucers/Elton John
Jetsex/Tonto's Expanding Head Band
The Jetsons/The Jetsons
The John Glenn Twist/Rio de Francesco
Jupiter Hollow/The Band
Kohoutek/Journey
Kokoku/Laurie Anderson
Life On Mars?/David Bowie
Loias of Sunhillow/Jon Anderson
The Lost Cycle/Rick Wakeman
Lost in the Stars/Marc Blitzstein
Luna Cruise/Kay Gardner
Major Tom (Coming Home)/Peter Schilling
Marscape (Album)/Jack Lancaster/Robin Lumley
Martian Boogie/Brownsville Station
Mr. Spaceman/The Byrds
Moon Flow/Kay Gardner
Moon Madness/The Jetsons
Moon Rocks/Talking Heads
Moon Walk/Joe Simon
Moonflight/Vik Venus
Mothership Connection (Album)/Parliament
Mysterious Traveler/Weather Report
Orion/Jethro Tull
Outa-Space/Billy Preston
Outer Space/Ken Nordine
Outer Space Blues/Bill Clifton
Outer Space Seeds/Russia
Perpetual Motion/Comus
Planet of the Apes/Gary Knight
Planet Rock/Afrika Bombaataa
Planetary Invasion/Midnight Star
The Planets/Deep Purple
Prayer from Outer Space/Roff
Praying to the Aliens/Gary Numan
Radio Station/EXP/Jimi Hendrix
Rapture/Blondie
Revenge of Vera Gemini/Blue Oyster Cult
Ride, Sally, Ride/Casse Culver
Rime Cube (Album)/Roger McGuinn
Rocket Countdown/Blastoff/Johnson Bros.
Rocket Fuel/Alvin Lee
Rocket Jockey/The Jetsons
Rocket Man/Elton John
Rocket Man/Pearls Before Swine
Rocket Polka/H.J. Lengsfelder
Rocket Queen/Guns n' Roses
Rocket Reducer No. 62/MC5
Rocket Ride/Johnny Greco
Rocket Ride/Kiss
Rocket Ride/Narvel Felts
Rocket Rocket/Billy May Orchestra
Rocket Ship/Hoagy Carmichael
Rocket Ship/Vernon Green & The Medallions
Rocket Ship Rag/Lindsley Love
Rocket Stream/Spacemen
Rocket to Heaven/Eddie Dean
Rocket Twist/Bobby Rydell
Rocket-trip/Jackie Lowell
Rockin' on the Moon/Billy Lee Riley
Rope Ladder to the Moon/Jack Bruce
Saucerful of Secrets/Pink Floyd
Set the Controls for the Heart of the Sun/Pink Floyd
Shoot the Moon/Moon Mullican
So Long Supernova/Comus
Solar Fires/Manfred Mann
Solar Prestige A Gammon/Elton John
Space/Julian Lennon
Space Age Love Song/Flock of Seagulls
Space Baby/Tubes
Space Boss/T. Rex
Space Captain/Joe Cocker
Space Child/Spirit
Space Child/UFO
Space Clown/Jobriath
Space Command/Herb Henson
Space Cowboy/Steve Miller Band
Space Crazy/The Jetsons
Space Flight/Sam Lazar
Space Girl/Julie Felix
Space Girls/Toni Basil
Space Hymns/Ramases
Space Invaders/Pretenders
Space Is Deep/Hawkwind
Space Junk/Devo
Space Monkey/Patti Smith
Space Oddity/David Bowie
Space Odyssey/The Byrds
Space Patrol/Country Joe McDonald
Space Philosopher/Eddie Lawrence
Space Race/Allen Bradley Quintet
Space Race/Billy Preston
Space Ritual/Hawkwind
Space Rock/Baskerville Hounds
Space Safari/Nazareth
Space Shanty/Khan
Space Shuttle/Buddy Rich
Space Song/Stomu Yamashta
Space Station #5/Montrose
Space Truckin'/Deep Purple
Space Walk/Lou Donaldson
Spaceman/Beast
Spaceman/Harry Nilsson
Spaceman/Journey
The Spaceman/Rick Wakeman
A Spaceman Came Traveling/Chris DeBurgh
Spaceman's Salute/Hank Edler
Spaceship/Spontaneous Combustions
Spaceship Earth/Sugarloaf
Spaceship Races/Carole King
Spaceship Superstar/Prism
Spirit/John Denver
Stardrive/Robert Mason
Star Baby/The Guess Who
Star Trek/Dreaming Spirit
Star Walk/Graham Central Station
Star Wars/Meco
Star Warts/Dickie Goochman
Starborn Suite/Steve Halpern
Starman/David Bowie
Starship/MC5
Starship/Paul Kantner
Starship Trooper/Yes
Starship from Above/Pat Wallace
Sure the Boy Was Green/Horslips
Telstar/The Tornadoes
Tentacles of the Dark Nebula/David Bedford
Third Stone From the Sun/Jimi Hendrix
Touch Down/Comus
Traveler/Steve Roach
Trip to the Moon/Gary U.S. Bonds
Two Thousand Light Years from Home/Rolling Stones
UFO/Reggie Knighton Band
UFO/Country Joe McDonald
UFO/Undisputed Truth
Under the Eye/Dennis Linde
Urban Spaceman/Bonzo Dog Band
The Ventures in Space (Album)/The Ventures
Venus and Mars Rock Show/Wings
Venusian Summer/Lenny White
Voyage to Uranus (Album)/The Atmospheres
Waiting for the UFOs/Graham Parker
The Walk of Ed White/Up With People
Walking in Space/Quincy Jones
Walking in Space/"Hair" Soundtrack
Walking on the Moon/The Police
The Warning/Rick Wakeman
We Are Normal/Bonzo Dog Band
Why Me?/Planet P

★ ★ ★ ★ ★

CONTEST

Send your (typed or neatly handwritten) entry to Spacesongs, Final Frontier, PO Box 11519, Washington DC 20008, before January 31.

SUMMER OF THE SPACE TIGERS

BY LES DORR, JR.

Nowadays, Bill Pogue looks more like your kindly old Uncle Fred than the raffish astronaut he once was, but boy, can he work a crowd.

"Look, I'm fifty-eight," Pogue chatters, turning his head parallel to the floor and waggling his flabby jowls to demonstrate the effects of zero-g. "Everything that's baggy or saggy just floats and hangs there. Horrible, isn't it?"

The hall shakes as a hundred space tigers roar with laughter, and Pogue segues into a graphic recital of how he and his Skylab crewmates belched, farted and otherwise stank their way around the world for 84 days in 1973. He especially delights in recalling the odious bubble of sweat that formed on Ed Gibson's back one day, its gelatinous mass wriggling obscenely as the astronaut worked Skylab's solar telescopes. "And *this*," Pogue deadpans, "is what they call the 'glamour' of spaceflight!" Just a typical lecture on a typical day at the International Space University.

PAT RAWLINGS

They came to work, play and dream at the International Space University, a melting pot for a new century.

It's hard to pin a label on ISU. It's more a passion than a place, a future as much as a present. No ivy-covered walls here; the "university" consists of a borrowed lecture hall, a bunch of computers and a couple of rooms in an unpretentious red brick building on the fringe of the MIT campus in Cambridge, Massachusetts. A million bucks may sound like a lot of money to start any new endeavor, until you have to put up 104 young space professionals for two months, *and* fly in a stellar cast of faculty and visiting lecturers from around the world.

Last summer's inaugural session of the International Space University was the brainchild of three cosmic *wunderkinder* who have championed space causes since their college days in the early 1980s. Todd Hawley, Peter Diamandis and Bob Richards met while developing Students for the Exploration and Development of Space, a campus activist group, and later collaborated to form the Space Generation Foundation (SPACEGEN).

SPACEGEN "test marketed" new ways to make young people aware of

INTERNATIONAL SPACE UNIVERSITY

their future possibilities in space, and one of those efforts ultimately evolved into the International Space University. "Of all the projects, ISU sat square in the middle of the three reasons people give money," said Hawley, the university's 27 year-old administrator. "There's a community interested in education, another interested in high technology, another in international affairs. But very little crossover among these groups takes place. We had to forge the 'welding spot' among those communities, and it was tooth and nail for the 14 months before the program began."

Even as they hustled up the money needed to fuel their dream of a multidisciplinary school for space, Hawley, Diamandis and Richards pondered just what sort of animal they wanted to create. It should have an international flavor, to be sure, and involve as many of the world's spacefaring nations as possible—including the Soviet Union and the People's Republic of China. "One of my goals was to meet my colleagues around the world, the people I'll be working with for the next 50 years," Diamandis explained.

Diamandis ended up shaking lots of hands. When word spread that the first eight-week summer session was to be held on the MIT campus this year, 350 applications inundated the ISU offices. The prospective students were the real space tigers of the world: predominately young, degrees out the wazoo, fluent in at least two languages, most already working in some kind of space endeavor.

Eventually, the list was pared to 104 candidates from 21 countries. The Chinese delegation represented the cream of their fledgling space establishment, including the chief designer of the Long March rocket booster and the head of China's life sciences research. And so what if the Soviets circumvented the admissions procedure by simply decreeing which twelve people they'd sponsor? The ISU staff and faculty deemed their participation too important to make an issue out of it.

Whatever their country of origin, students seem to develop similar ways to cope with that bane of their existence, the boring class. During a lecture on systems engineering—a real snoozer, for diehard techies only—some listeners doodle, several doze. Love blooms in the back row, as two students tenderly hold hands and exchange longing glances. Three Soviets sit together. Two of them take notes intently; the third is reading a Time *article on Gorbachev's widespread reforms of the Soviet political system....*

STU ROSNER

And so they arrived from the four winds on June 20, brimming with enthusiasm and idealism—tempered, at least in their minds, with reality. "Initially I was skeptical. I laughed at things such as 'mass drivers,'" volunteered Taber MacCallum of New Mexico. "Now I see that these things can really be done, that Moon mining could actually provide the economic environment to make commerce in low Earth orbit profitable."

Some of the international students had more down-to-Earth concerns. "I expect to use the knowledge I get here to bring the rest of the world closer to Africa," declared Kenya's Wilson Oguya. His altruism was echoed by Mohammed Alhomeida, an Americanized Saudi who said simply, "It will be nice if I can work with issues related to both societies."

Almost all of the students had corporate or national sponsors who had forked over the ten grand for tuition. A handful received only "conditional acceptance," a friendly ISU-phemism meaning, "Come on in—but bring cash!"

Canada's Connie Robinson is typical of the lonely souls who had to scrounge up the money themselves to attend the university's summer session. A political scientist with a master's degree from the University of Calgary, she struck out with the corporations she contacted, and failed to interest the print media in her quest. "Finally, a Calgary TV station picked up on my story, and donations began rolling in from private citizens," she recalled. "Then Chris Trump (an ISU board member and president of SPAR Aerospace) started rattling the can for me. He cinched things with a dinner speech at the University of Calgary, where the faculty chipped in $6,500 U.S."

Connie smiled at her fundraising success: "The funny thing is, I'm not even a business major!"

SPACE TIGERS

You'd expect a gaggle of young people from around the world to show diversity in dress, but most ISU students have adopted Early American Very Casual as their wardrobe of choice. Jeans and shorts predominate; shirts are tastefully done, with some exceptions: Ron Schaefer's med school scrubs sport a sinister fly above the proud scatological motto "COPROPHAGIA ET FATALIS." Look it up.

In flowing white robe and burnoose, only Saeed Al-Dhaheri of the United Arab Emirates wears customary ethnic attire. Unless, of course, you count the guy who shows up every day in immaculately pressed pants, starched white shirt and unstylish bow tie.

Somebody says he looks like a traditional space nerd....

While working on ISU's lunar design project, Tom Kubr of Switzerland learned that different cultures have their own unique approaches to problem-solving.

Connie Robinson managed to drum up most of her own tuition money, even though she's "not a business major."

The curriculum for the ISU's first summer session revolved around several specialized areas such as policy and law, life sciences and space architecture, but the program was deliberately designed to broaden the students' horizons. Ideally, the engineering types would find they couldn't ignore "human factors;" devotees of softer disciplines would flesh out the philosophical aspects of space exploration with some nuts-and-bolts realities.

The interdisciplinary approach was the reason many of the students came to ISU. Paul Robinson of the U.K. and Canada, who was schooled in aerodynamics, applied because he "just didn't want to limit myself to a single career." Vadim Vlasov was pursuing a doctorate in cosmonautics at the Moscow Aviation Institute, but chose to study policy and law at ISU; Chinese mathematician Menghuai Chen opted for business and management.

"It's an 'ivory tower' atmosphere, but maybe that's what we needed," said Clarence Korendyke, a young physicist from the Naval Research Laboratory in Washington, D.C. "I know I've learned a lot about space business as it's carried out by NASA and the European Space Agency."

Some students were more dubious. Canadian Stephane Lessard thought "an interest in other specialties is great, but so many lectures in a row dulled our attention span." And Ohio's Virgil Vulcu—the inimitable "Doc V."—may have spoken for the majority of his ISU companions when he said "the 14-hour days got old after a while."

One of the qualities the ISU faculty looked for in successful candidates was leadership, and the students didn't let them down after they arrived. On their own, they set about restructuring their class project—the design of a multi-national lunar base—more to their liking. They even organized themselves into functional sub-groups to take advantage of different areas of expertise and interest.

As in real life, however, the varied backgrounds and work ethics took a while to mesh. "There are pragmatists, and then there are dreamers," advises laid-back Joe Kennedy of Southern California. "The emphasis seemed to be on 'costing the man-machine interface' and so on. I really wanted to infuse the art, the more nebulous stuff—get some kind of fusion, a way that we could be more creative."

The Soviet students had an especially difficult time breaking out of their traditional approaches to problem-solving. "The Russians weren't used to the way Westerners brainstorm chaotically. They think we waste way too much time on organization," said Switzerland's Tom Kubr. And Alexander Khalimon, a mechanical engineer from Moscow, candidly agrees: "After three weeks, we had no real product. Phase

A (of the lunar design project) was ending, and we hadn't even decided how to do it!"

But there was unanimous acclaim for Jinhe Wei, the soft-spoken chief of China's space biomedical program. He awed the younger students—Wei was somewhere on the far side of forty—with his storehouse of knowledge, and often played mediator when the atmosphere heated up in the lunar design sessions. "He really is an amazing guy," Joe Kennedy says. "After everybody argued themselves out, Mr. Wei would jump in with a real, applicable solution."

Of course, the whole purpose of having an *International* Space University and an *International* Lunar Initiative was to expose the students to just that sort of cultural give-and-take: to accustom them to blow-ups and frustrations, to make them sacrifice habit and national differences to the god of meaningful cooperation.

"It was what I call 'ant work'," Brazilian journalist Fabiola de Oliveira recalled. "A lot of little contributions eventually added up to a big result over time."

Even the Soviets overcame their initial distaste for Western methods and got into the spirit of the task: "Back home, I usually have a defined problem to solve," said Mikhail ("Call me Mike") Elizarov. "But I'm carrying back new ways of thinking, new ways to study things. And it was so interesting, this interface with people from other countries."

All work and no play makes space a dull place. And God, these ISU people know how to party. The "Muddy Charles" student bar at MIT becomes an unofficial ISU annex in the evening, with the beer bust cum *bull session presided over by resident partymeisters Paul Robinson and Doc V.*

As the beer flows, the conversation rambles from the idiosyncrasies of the faculty, "So-and-so's such an [expletive deleted], so-and-so #2 won't have anything to do with him") to the feminine charms of Soviet student Marina Kuznetsova (universally hailed by ISU males as a blond Venus who turns heads in any language). There's also a playful bit of intrigue in the ivory tower: who's the KGB agent? Speculation blearily focuses on Vadim Vlasov and Dmitri Belashov, the apparent leaders of the Soviet cadre, but there's a fair amount of sentiment for one of the outspoken Vladimirs.

(And is it really just a bunch of half-lit Westerners indulging in some Rooski-bashing? When I asked Marina earlier that day for an interview with her and the other Soviets, her answer may have been just coincidence: "Yes, I think that is possible. But you must ask Vadim or Dmitri....")

"Space is a new start for Earth. It's as (ISU board member) David Webb said in the welcoming ceremonies—spaceflight spells the death knell of the nation-state, because from space, astronauts and cosmonauts aren't aware of any borders."

This year's graduates won't have to wait long for reinforcements. ISU's 1989 session, which will feature a different cast of characters at a European university, is already in the works. By 1992,

Joe Kennedy: searching for a fusion of art and engineering.

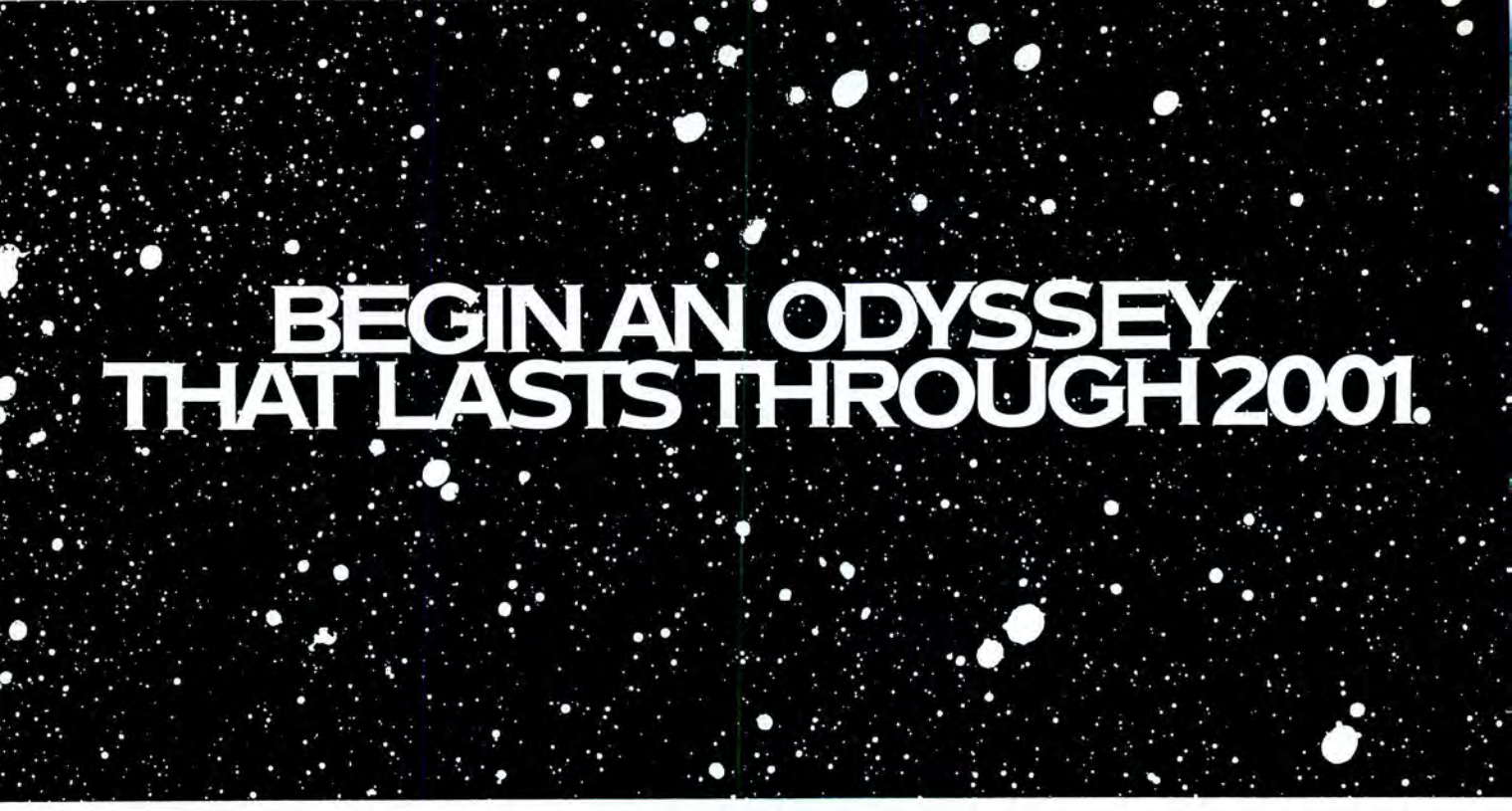
A Chinese proverb is plastered all over the literature from the International Space University:

> To plan for a year, plant a seed;
> To plan for a decade, plant a tree;
> To plan for a century, educate
> the people.

The students of the university's Class of '88 see themselves as planners for the coming century, taking their experience and fanning out to "educate the people" about the value—and inevitability—of space cooperation.

Some consider the practical aspects; India's Hari Saxena feels that "space is really the only way for developing countries to participate in international cooperation." Others, like Paul Robinson, have a grander view: the International Space University hopes to be a permanent institution, with a full-fledged master's degree program.

Even if ISU remains no more than an interesting footnote to space history, the students who pioneered the dream this summer will carry its lessons with them throughout their careers. Perhaps the students' youthful enthusiasm will dull as they tangle with the constraints of national bureaucracy and corporate policy. They may find that political and cultural differences can disappear for a summer, but not for a lifetime. But maybe they'll actually pull it off, and sail hand-in-hand to the Moon and planets as the doubters watch enviously from the ground. They damn sure *believe* they can do it. □



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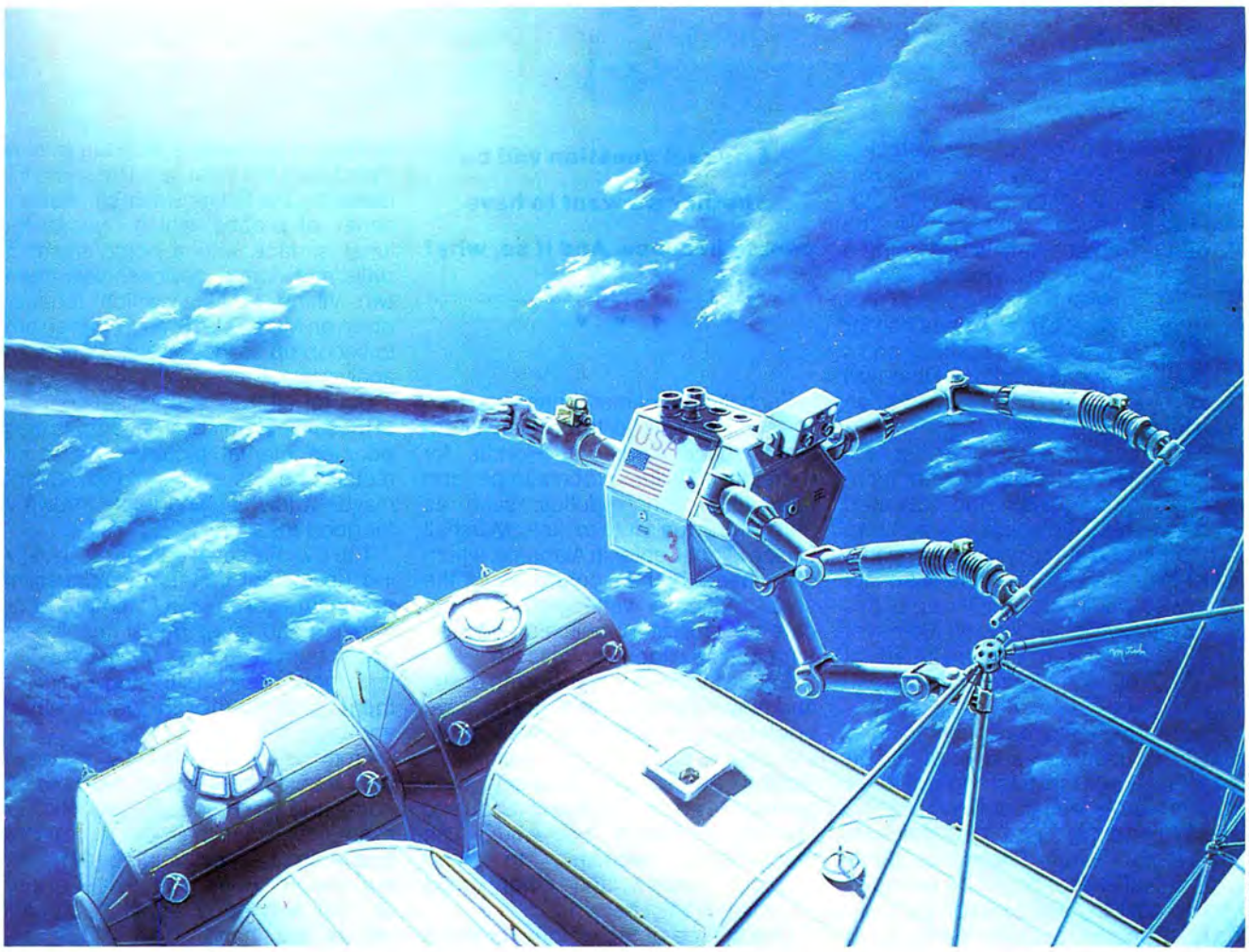

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ROBONAUTS

They aren't yet in the same league with C3PO and R2D2, but they're getting closer every day.

BY GREG FREIHERR

Floating in the void of space, tiny engines spitting fire, these will be the new pioneers: space robots with mechanical arms, cameras for eyes and computers for brains.

"We are on the threshold with robots," says John Oberright, manager of NASA's most ambitious robotics program ever. "Not the hard-line automation robots that you see in factories, but robots that can operate in less structured environments." Earth orbit, for example.

The space agency now has plans on the drawing boards for a whole family of robots, including an arm that can be used to assemble the space station; a free-flying retriever for snatching objects—or astronauts—drifting away from the station; and a sophisticated robot worker that can move from place to place, doing whatever chores are needed. Best of all, these robots require no technological breakthroughs, no sudden leaps forward. They simply incorporate the best and brightest ideas developed over the past several decades of research into robotics.

An early model robot arm already has flown many times onboard the space shuttle, hauling satellites into

and out of the vehicle's cargo bay. The Canadian company SPAR Aerospace, which built the shuttle arm, is designing a more advanced version for NASA's space station Freedom. Current plans call for it to be mounted on a mobile platform that will scuttle across tracks on the station's girder-like frame.

Similarly, the retriever robot will merely extend already proven technology. It combines the Manned Maneuvering Unit jet backpack, flown eight times on shuttle missions, with a robot that "stands" where an astronaut otherwise would be. A mock-up of this EVA (extravehicular activity) Retriever already has been demonstrated at NASA's Johnson Space Center in Houston.

The robot being designed to help construct, maintain and expand the space station is the most sophisticated currently on American drawing boards. The technology for this machine (called the "Flight Telerobotic Servicer" in NASA-ese) might be tested in orbit as early as 1991. A prototype could be ready in plenty of time to help build and service the station in the mid-1990s.

Not only will these robots make astronauts more productive, they'll reduce the need for humans to work outside the station, and cut down on some of the risks that accompany routine chores.

"The first time you perform a task in space, it's very exciting," says Dr. Guilio Varsi, manager of the Automation and Robotics program at NASA's Jet Propulsion Laboratory. "It's very challenging; it's unknown. But when the same task or activity is repeated a hundred or a thousand times, it becomes unbearable, and perhaps intrinsically more hazardous, because the attention of the operator becomes a lot less concentrated."

The new generation of NASA robots is taking shape as part of a grand plan being hatched at the agency's Goddard Space Flight Center in Greenbelt, Maryland. Other NASA centers are involved in robotics work as well, and robotics manager Oberright says the researchers are even looking to other government agencies, private companies and universities—"anyplace we find things that might be applicable."

The real question will be whether we *want* to have people in space. And if so, why?

▼ ▼ ▼

Each NASA center brings its own special interests to the project. Kennedy Space Center in Florida, for example, is building robots to perform hazardous launch duties, such as transferring fuels into rockets. Marshall Space Flight Center in Alabama, which is in charge of the laboratories for the space station, is working on robots to care for laboratory animals and perform routine experimental tasks.

Space factories for producing drugs and new materials in zero-gravity have often been mentioned as likely applications for robotics. And recently, the Boeing Aerospace Company suggested the addition of a farm module to the space station that would use mechanized "workers" to tend potatoes, lettuce and other crops grown in dirtless trays.

One source of technology for these space-based robots is the manufacturing sector on Earth—industrial machines that work on assembly lines doing repetitive jobs. Another source is the nuclear and underwater industry, where "telerobots" working in unstructured environments are commanded by remote operators to perform complex tasks.

NASA's Oberright says that the agency intends to "marry" industrial robotics and telerobotics, and the offspring from that marriage may extend far beyond the confines of space station Freedom. Already engineers are thinking about using robots to pilot the Orbital Maneuvering Vehicle, an orbital ferry that would leave its space station port to visit and fix satellites.

More sophisticated machines are being considered for scouting missions to the Moon and Mars. The Soviets are planning to send rovers to the Martian surface in the 1990s, and NASA is considering a robot surveyor that would send samples of the Martian surface back to Earth sometime early in the next century.

These interplanetary explorers can trace their heritage back to the Surveyors of the 1960s, the flagships in America's rush to the Moon, which landed on the surface and dug shallow trenches in the lunar soil. They were followed by the Soviet Union's Lunokhod series of probes, which roamed the lunar surface with a complement of drills and coring devices. Next came two Viking landers, which touched down on Mars in 1976, each with an arm to scoop up soil for onboard chemical analysis.

But for all their sophistication, none of these mechanical creations fits most people's mental picture of a robot: metallic bodies, humanoid voices and maybe a few flashing lights thrown in for good measure.

The EVA Retriever comes close to living up to that image. It replaces an astronaut's eyes with computerized tracking and ranging systems. It even obeys human voice commands to find its targets, track and maneuver toward them, grab them with robotic hands and bring them back to base.

From inside the station, an astronaut will be able to use any of 200 words to command the Retriever. "Search!," for example, causes the robot to look for a tool or an astronaut floating away from the station. "Reach!" makes it extend its arm with hand open; "Grapple!" closes the hand. Best of all, the Retriever will acknowledge each command with a human voice response (and won't ask for a Milk Bone in return).

Johnson Space Center is building the Retriever's body and hands and designing the computer software, while contractors are developing its 3-D imaging laser radar, video tracking system and voice control system.

Meanwhile, two aerospace firms—Martin Marietta Space Systems in Colorado and Grumman Aircraft in New York—are competing for the right to build the most sophisticated of NASA's planned robots—the Flight Telerobotic Servicer, or FTS.

The FTS will have a body—although it will probably look more like a piano than a person—and will have at least three arms. Each arm will have a choice of "end effectors" (grips suited to different jobs), each with sensors for measuring force, torque and position. Stereo television cameras will substitute for eyes. A computer brain will take advantage of the latest developments in artificial intelligence to "think" through simple problems.

Some of these robots will be high-tech dock workers, unpacking the shuttle cargo bay. Others will be janitors cleaning up the mess after a

DATA BASE

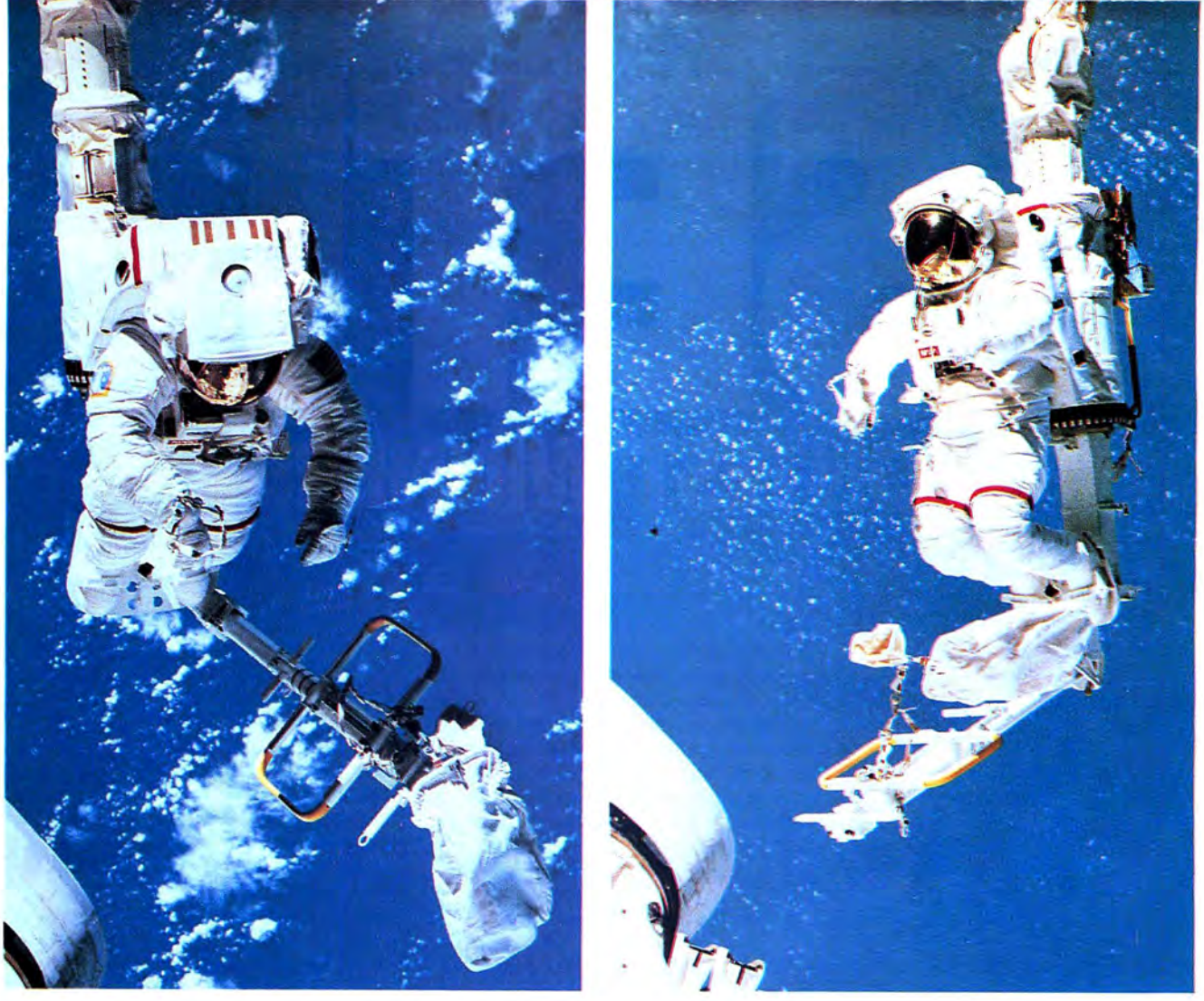
Target: Moon! Lunar Exploration Missions

MISSION	LAUNCH	BY	DESCRIPTION
Luna 1	January 2, 1959	USSR	Also called "Mechta" (Dream); passed within 3,750 miles of Moon
Pioneer 4	March 3, 1959	US	First successful US flight; missed Moon by 37,000 miles
Luna 2	September 12, 1959	USSR	First man-made object to impact lunar surface
Luna 3	October 4, 1959	USSR	Relayed first images of Moon's hidden side
Ranger 3	January 26, 1962	US	Landing attempt; missed Moon by 22,862 miles
Ranger 4	April 23, 1962	US	Command system failed; crashed on lunar farside
Ranger 5	October 18, 1962	US	Solar panels failed; missed Moon by 450 miles
Luna 4	April 2, 1963	USSR	Signals lost as probe passed within 5,800 miles of Moon
Ranger 6	January 30, 1964	US	Crashed in Sea of Tranquility; TV failure prevented picture return
Ranger 7	July 28, 1964	US	Sent back 4,300 images before impact in Sea of Clouds
Ranger 8	February 17, 1965	US	Relayed over 7,100 lunar photos enroute to Sea of Tranquility
Ranger 9	March 21, 1965	US	Returned 5,814 close-up images showing details as small as 10 inches
Luna 5	May 9, 1965	USSR	Landing attempt; crashed due to retrorocket failure
Luna 6	June 8, 1965	USSR	Mid-course error caused probe to miss Moon by 100,000 miles
Zond 3	July 18, 1965	USSR	Mars probe systems test flew past Moon, sent back 25 lunar views
Luna 7	October 4, 1965	USSR	Retrorocket timer malfunctioned; crashed west of Kepler crater
Luna 8	December 3, 1965	USSR	Crashed due to retro timer failure
Luna 9	January 31, 1966	USSR	Landed in Ocean of Storms; relayed first photo from lunar surface
Luna 10	March 31, 1966	USSR	First successful lunar orbiter; transmitted data for two months
Surveyor 1	May 30, 1966	US	First US soft-lander; sent back more than 11,000 images
Explorer 33	July 1, 1966	US	Intended for lunar orbit; missed Moon due to excess velocity
Lunar Orbiter 1	August 10, 1966	US	Entered Moon orbit 8-14-66; mapped Apollo landing sites
Luna 11	August 24, 1966	USSR	Lunar orbit mission; may have been only partially successful
Surveyor 2	September 20, 1966	US	Lost control enroute to Moon, crashed 9-23-66
Luna 12	October 22, 1966	USSR	Orbited Moon, relayed pictures and data for 86 days
Lunar Orbiter 2	November 6, 1966	US	Continued mapping mission, landing site reconnaissance
Luna 13	December 21, 1966	USSR	Touched down 12-24-66; sent back pictures, tested soil density
Lunar Orbiter 3	February 5, 1967	US	Transmitted 422 medium- and high-resolution lunar photos
Surveyor 3	April 17, 1967	US	Landed 4-20-67. Components recovered by Apollo 12 crew in 1969
Lunar Orbiter 4	May 4, 1967	US	Mapped 99% of Moon's visible side from near-polar orbit
Surveyor 4	July 14, 1967	US	Signals lost before landing—crashed in Moon's Central Bay

DATA BASE

Target: Moon! Lunar Exploration Missions

MISSION	LAUNCH	BY	DESCRIPTION
Explorer 35	July 19, 1967	US	Orbited Moon 7-22-67; studied dust particles, lunar gravitational field
Lunar Orbiter 5	August 1, 1967	US	Studied special interest areas, took 212 photos
Surveyor 5	September 8, 1967	US	Landed in Sea of Tranquility, relayed more than 18,000 images
Surveyor 6	November 7, 1967	US	Touched down in Central Bay; moved 10 feet in first lunar "liftoff"
Surveyor 7	January 7, 1968	US	Landed near Tycho crater, sent back more than 21,000 surface views
Luna 14	April 7, 1968	USSR	Second-generation lunar orbiter; mapped Moon's gravitational field
Zond 5	September 14, 1968	USSR	Test for manned flight; circled Moon, returned to Earth 9-21-68
Zond 6	November 10, 1968	USSR	Similar to Zond 5; carried biological specimens, stereo camera
Apollo 8	December 21, 1968	US	Borman, Lovell and Anders made first manned flight to lunar orbit
Apollo 10	May 18, 1969	US	Stafford, Young and Cernan conducted dress rehearsal of Moon landing
Luna 15	July 13, 1969	USSR	Possible sample return mission. Crashed in Moon's Sea of Crises
Apollo 11	July 16, 1969	US	Armstrong, Collins and Aldrin took "one giant leap for Mankind"
Zond 7	August 7, 1969	USSR	Circumlunar flight. Shot color photos of Moon and Earth
Apollo 12	November 14, 1969	US	Conrad, Gordon and Bean. Second manned landing, in Ocean of Storms
Apollo 13	April 11, 1970	US	Lovell, Swigert and Haise aborted Moon landing. Oxygen tank exploded enroute
Luna 16	September 12, 1970	USSR	Sample return; ascent stage brought back 101 grams of lunar soil
Zond 8	October 20, 1970	USSR	Circumlunar flight. Photographed Moon's far side from 660 miles
Luna 17	November 10, 1970	USSR	Carried Lunokhod 1; Moon rover traveled 6.5 miles across lunar surface
Apollo 14	January 31, 1971	US	Shepard, Roosa and Mitchell. Third manned landing, in Fra Mauro
Apollo 15	July 26, 1971	US	Scott, Worden and Irwin took first lunar "rover" to Moon's Appenine region
Apollo 15 P&F	August 4, 1971	US	Small particles and fields satellite released by Apollo 15 mission
Luna 18	September 2, 1971	USSR	Probable sample return; crashed near Sea of Fertility
Luna 19	September 28, 1971	USSR	Orbited Moon, measured lunar magnetic and gravitational fields
Luna 20	February 14, 1972	USSR	Soft-landed 2-21-72; returned material from lunar highlands
Apollo 16	April 16, 1972	US	Young, Mattingly and Duke. Fifth manned landing, in Descartes
Apollo 16 P&F	April 23, 1972	US	Deployed by Apollo 16, remained in orbit until May 1977
Apollo 17	December 7, 1972	US	Cernan, Evans and Schmitt made last manned landing, in Taurus-Littrow valley
Luna 21	January 8, 1973	USSR	Delivered Lunokhod 2; rover traveled 23 miles inside Le Monnier crater
Luna 22	May 29, 1974	USSR	Lunar orbiter; conducted experiments for 15 months
Luna 23	October 28, 1974	USSR	Landed in Sea of Crises; drilling rig failure prevented sample return
Luna 24	August 9, 1976	USSR	Touched down 8-18-76; brought back 170 grams of lunar material



day's work, or perhaps apprentices in the construction of the space station. Robots will be used to replace space station modules, install antennas, or act as tireless watchmen patrolling the outside of the station.

They may even be put in charge of repairing satellites, under the supervision of astronauts. "We intend for the robots to take some of the load off the astronauts," Oberright says, "so the crew is more available to do the kinds of things they are good at—making decisions and performing scientific experiments."

But astronauts still will need to be on hand to push the box-like bodies of their mechanical helpers from place to place, using a manipulator arm attached either to the shuttle or the space station. At first the instructions will be detailed: An astronaut onboard the station might use hand controllers or be hooked up to a control panel so that every human action will be copied exactly by a robot arm.

More advanced "force feedback" systems would allow a human operator to judge the pressure applied to an object by the robot. According to Varsi, the operator will have "a much greater sense of his presence at the worksite, even though he is remote."

The robots will be programmed to recognize when too much force is being applied, so they don't snap off screws or bend trusses. With an internal sense of control, they eventually will be allowed to perform some tasks on their own—perhaps single chores like replacing a module or driving in a screw.

The Flight Telerobotic Servicer (page 47) will draw on NASA's experience with humans using the shuttle's robot arm (above and below).

What we learn about robots in space, says Varsi, may also help in industrial settings on Earth: "Many of the elements that are being developed will be of great help... in what is called 'flexible manufacturing' or 'flexible automation'... This allows machines to operate under conditions that are not exactly as established in the specifications."

The prospect of robots scurrying around in space raises a legitimate question—in some cases, might they eliminate the need for people altogether?

"For the purpose of making measurements, we could almost exclusively use robots," Varsi says. "We can use vision systems. We can relay information back to Earth, make decisions on the ground and send commands up to orbit. We can certainly have automated facilities on the planets. We can send rovers that could receive commands no more than a few times a day, perhaps just even once a day."

These early space robots inevitably will give way to mechanized Solar Sys-

continued on page 62

SETI CONTEST WINNERS

During the last few months, we at *Final Frontier* have received communications proving that intelligent life truly does exist in the universe—at least among you, our readers.

In answer to our contest on the impact of a verified signal of extraterrestrial intelligence ("What Happens if It Works," June 1988), you sent us dozens of letters from every part of the United States and Canada. Almost all of you forecast a profound effect on human society. Most thought the changes to human institutions such as government and religion would be immediate and long-lasting. Others thought we'd go back to something approaching "business as usual" after an initial groundswell of excitement.

Many of you had questions as well as answers. Would an extraterrestrial civilization be benign or hostile? Would contact (and eventually, real communication) represent a deliverance of the human race from its own supposed evils, or pose a threat to our very existence by assimilating us into some sort of galactic society?

Quite a few predicted that NASA's fortunes would soar as the result of extraterrestrial contact, while several saw the sinister specter of a government coverup to hide the truth from unsuspecting citizens. (One writer claimed to be in regular contact with our E.T. buddies, despite government secrecy. The same correspondent urged us "not to believe everything we hear." We didn't.)

Ultimately, three of the responses stood out from the rest. The authors will receive a year's subscription to *Final Frontier* and a NASA video on the agency's SETI project.

A graceful tip of the radio telescope dish to all you thoughtful readers who took the time to write. And now, the envelopes, please....

I think that most of our society would get a real scare. We would probably demand more nuclear missiles and other weapons to protect ourselves.

For space scientists it would be a breakthrough to communicate with aliens. New theories would come about. The aliens would be more advanced than us—to be able to understand our message and give us a signal—and we could learn a lot from them about ourselves and our environment.

We would also be putting ourselves on the spot: if they are more advanced, they could spoil us. We would be learning everything from them and we wouldn't try to figure anything out by ourselves. By doing that we would endanger our very existence.

—Veronica Ciolfi (age 13)
Weston, Ontario, Canada

What happens if SETI works? Not much, I fear.

However, I offer the following assumption: Our SETI contact is merely that—contact. We identify (maybe locate a zillion miles away) a presence but receive no message or information from it. I don't want to discuss the possible contents of any alien broadcasts. Science fiction writers get paid to do that.

Initially, there will be an enormous hullabaloo. We will suddenly find that everybody, especially politicians, has been strongly supportive of the SETI program since its inception. There will be a spate of sci-fi flicks and related commercial ventures. Most people *will* believe another Intelligence has been "found," but many folks, especially among certain religious groups, will *never* believe it. The lunatic fringe will flower, TASS will "prove" that the aliens must have evolved into a true communist society....

This phase will last for a couple of years. Ceteris paribus, the excitement arising from First Contact, will slowly fade into the back of the public mind. Soap operas, Superbowls, and scandals will re-assert their dominance.

The good news is that many folks of a more far-sighted nature will turn their energies from SETI to CETI—sounds the same but means "communication with" instead of "search for."

CETI will be much more exciting than SETI. I sincerely hope to see this happen. I pray that our SETI contact does not turn out to be a navigation beacon left operating in "automatic" by a long-extinct civilization.

But the beacon would be better than nothing.

—William W. Daugherty,
Lieutenant, USN
San Diego, California

SETI Hears a Beep

The Russians will say, "It doesn't exist.
Except as a trick by a Capitalist!"

The British will comment, "Oh,
deary me,
They might have waited till after tea."

The Security Council (United Nation)
Will praise and deplore in the same
proclamation.

The Japanese, at a breakneck pace,
Will market a movie, "Ninja from Space."

Some entrepreneurial guy or gal
Will start a religion in southern Cal.

East Indian Lamas, their faces aglow,
Will quietly murmur, "We told you so."

Colombians will fill a ship with cocaine
And set out for the source like a
midnight train.

And some folks won't believe it, but, listen, E.T.:
Phone EARTH 555-1753.

—Suzanne Jacques
Long Beach, Mississippi

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REVIEWS

The Monuments of Mars:
A City on the Edge of Forever
By Richard C. Hoagland
North Atlantic Books
348 pages. $14.95.

By Tony Reichhardt

There is a rock formation on the surface of Mars, photographed by NASA's Viking spacecraft in 1976, that looks like a human face. No doubt about it. It *looks* like a human face.

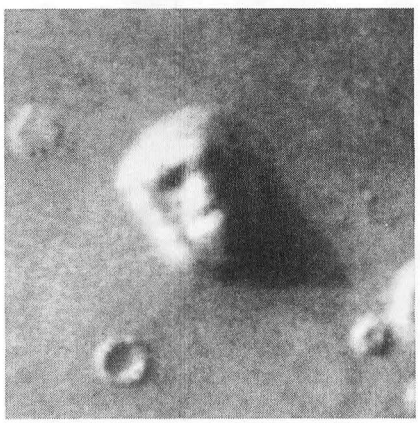
Now most people, like the NASA scientists who first saw the photographs, say "Hey! How about that!"—the same reaction most people have to those cartoon items in Ripley's Believe It or Not!: "Potato in the shape of Abraham Lincoln. Submitted by Mrs. Betty Mims of Spivey, Kansas."

Most people, that is. Not Richard Hoagland.

Instead, he takes The Face as a departure point for 348 mind-numbing pages of speculation, fantasy and downright foolishness, all carefully disguised as scientific inquiry. By the time he's done, the reader is breathless from a wild goose- chase that includes mysterious beings from other stars, mysterious "suspended-animation" chambers, mysterious pyramids, mysterious (and inexplicable!) Space Visitor myths from ancient Sumer, and all the other staples of National Enquirer science.

Maybe it should come as no surprise in an age where Presidents consult astrologers, but The Face on Mars is back. And now its proponents are demanding that we take it seriously. No longer is The Face just fodder for the grocery store checkout aisle. The experts, Richard Hoagland tells us, have taken a closer look, and by God, there's *something there!*

It's hard to tell when Hoagland really believes what he's saying, and when he's just *suggesting*. But his oh-so-careful detective work has led him to a conclusion that goes something like this: Aliens came to our solar system from another star. They couldn't land on



Earth, because the gravity was too strong. So they set up house on Mars—in Pyramids and in underground chambers that (when you squint the right way) look like honeycombs in the NASA photos. Then they built a big face, apparently for our benefit. And the face doubles as a Stonehenge-type solstice marker, clever aliens.

Also, they created the human race.

Hoagland admits that this is a lot to swallow, but, hey, the evidence is there. A science writer who has long been on the outskirts of NASA's planetary exploration program, Hoagland began scrutinizing the Viking photos in 1983, several years after two other researchers revealed that what *appeared* to be a face in one of the images *also* appeared to be a face in a *second* photo!

Hoagland got out his magnifying glass and his ruler for a closer look, and found a "City" (a grouping of pyramid-shaped rock formations near The Face, and according to Hoagland, the *real* key to the story). Then, somewhere along the line, he and his band of amateur sleuths got lost in the fiction they had begun to create the moment they started calling these objects a "Face" and a "City."

You can actually see this happen over the course of the narrative, which chronicles The Discovery, then The Investigation, followed by The Implications. At first Hoagland is careful to put all terms like "Face" and "City" in quotation marks (if you removed the quotes, the book would be about 50 pages shorter). He also includes plenty of disclaimers like "...if it *was* really a face."

But pretty soon he starts making assumptions based on those assumptions, and calling them new "data." He's apparently forgotten who it was who made all this stuff up in the first place.

The whole book, in fact, is a logician's nightmare. One particularly circular line of reasoning is used to determine that The Face, which up until now we've thought was only meant to be viewed from above, was also a marker for the Sun- and Earth-rise, as seen (through the "Face's" "mouth") from the surface. Hoagland figured all this out very carefully, with lots of measuring and lots of important-looking calculations, which he patiently explains to us.

But what it really amounts to is that he has assumed a certain alignment, and then worked backward to find a time when the physical conditions required for such an alignment were fulfilled. That's how he dates the cluster of "monuments" that he modestly claims is "something so big, so important, that just possibly it could affect the future of the world" at approximately half a million years old.

Then, when even the other Face-ites try to tell him that his pattern of "honeycombs" (really "suspended animation" chambers for sleeping aliens, remember) are simply artifacts of the computer enhancement process used to improve the quality of the photos, Hoagland finds another, subtler pattern, *underneath* the bogus pattern, that just *may* be (could it possibly be?) *real!*

Eventually one gets tired of pointing out all these flaws; most of the time Hoagland is arguing with himself, anyway. But occasionally he talks to other people, too, and their reactions are among the most telling anecdotes in the narrative. (The scientific community, in case you're wondering, almost unanimously believes that there is absolutely nothing, aside from an inter-

esting shape, to The Face. Natural pyramid-like objects and other weird geological formations exist all over Mars.) Hoagland reveals more than he probably intends to when he recounts stories about friends and colleagues looking at their watches, or puffing on their pipes, or just staring blankly while he excitedly tells them about his latest theory or quest for "data." (Even the book's publisher, in his preface, backs off from what he calls the "hypothesized terrestrial connection.")

This is a maddening book to read, because at the same time Hoagland is indulging his own fantasies, he's talking the talk of a terribly skeptical and hard-headed scientist. It's a convincing illusion, with all the right ingredients thrown in:

The use of statistical "evidence": "Less than one chance in a *trillion trillion* that the objects clustered on this infinitesimal spot of Mars...are there by accident!"

The lack of any other believable answer: "To expect this degree of precision from several separate elements *by chance* was asking for a lot—a remarkable fortuity, or a virtual miracle." (Unlike the alien visitors theory, of course.)

The patronizing remarks to the reader: "If you're a bit confused, you're not alone. But follow..."

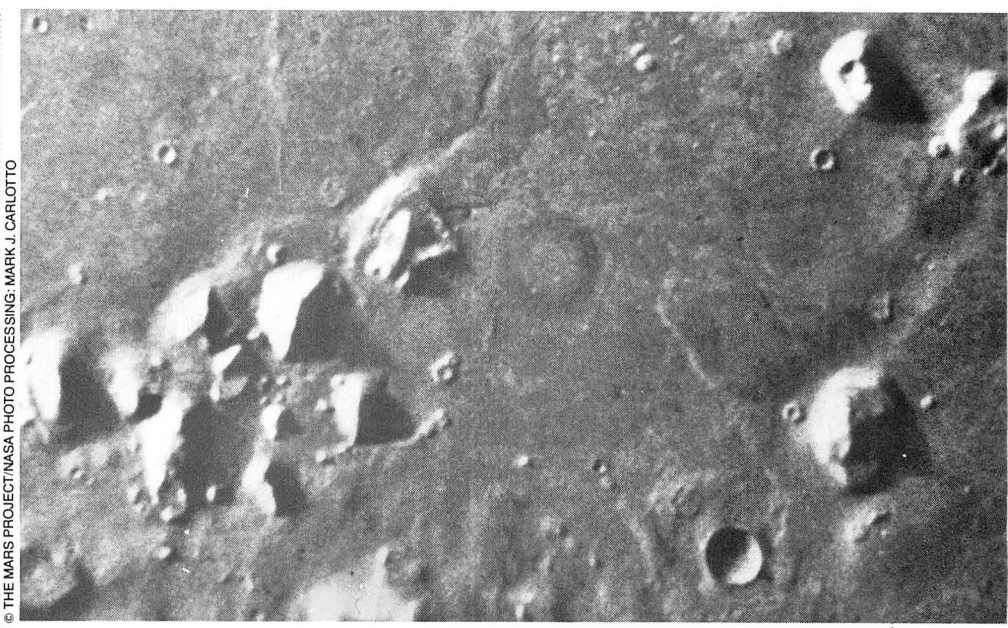
The "Suddenly It All Fell Into Place" discoveries: "'Oh my God,' I said softly, in the night with no one to hear me except the clock and the cat."

The guard against jumping to outrageous conclusions: "My inner watchdog (just back from chasing the cat, probably) warned, 'Watch it! You're really speculating here...'"

The name-dropping of famous scientists: "Now, under the National Academy dome, Carl wanted to talk to me—the guy behind the fuss."

The dismissal of other kooks: "The damage caused by [Erich Von Daniken] to the very *concept* of serious investigation of claims of ancient visitors to Earth from 'outer space' has been incalculable."

Predictably, Hoagland tries to get us on his side by posing as The Little Guy Who Won't Be Listened To. Everyone knows that any Really Important Breakthrough needs a Scoffing Establishment to ridicule it. After all, they laughed at Columbus, and Einstein's teachers thought he was a dolt. Unfortunately, for every Einstein or Columbus there are ten thousand dolts who deserve to be laughed at.



© THE MARS PROJECT/NASA PHOTO PROCESSING: MARK J. CARLOTTO

A Martian Rorschach test: The "Face" (upper right), and "The City" (upper left) "discovered" by Richard Hoagland.

That Hoagland has been heavily influenced by all the science fiction he's read is obvious from the very first chapter. The book is full of references to the stories of Arthur Clarke and Ray Bradbury, and Uhura, Scotty and Chekhov crop up frequently. At times, when he's at home alone, bent over the photos of his "City" with magnifying glass and ruler in hand, Hoagland says he *almost* can't help thinking about monks in hooded robes, or "Martian armies, pennants flying." The sad thing is that he doesn't even seem to realize how much these stories have infected his "science."

So why even bother with The Face controversy? One worry is that The Face will obscure the legitimate reasons for exploring Mars—the dozens of real mysteries that *don't* involve Olympic-class stretches of the imagination.

Hoagland is too careful to say that any of his theories have been proven. Posing as a hard-headed scientist, he claims that all this stuff about Cities and Faces is only a hypothesis that needs to be tested rigorously—by a return mission to Mars.

Great. We all would like to see a mission to Mars. And we'd all like to see the NASA SETI program make contact with extraterrestrials. And wouldn't it be nice if we could scrap all our patient long-term strategies, bypass the budget battles and economic factors and launch a mission tomorrow that would be so compelling, so important, that the whole world would wait on pins and needles for an answer?

Well, yes. But folks, The Face ain't it.

On the very first page of his book, Hoagland quotes Ray Bradbury: "If Mars is empty...we will fill it."

Let's do it. But please, not with Faces, or Bunny Rabbits, or Potatoes Shaped Like Abraham Lincoln. □

BOUNDARIES

Hunting for Near-Earthers

One asteroid impact can ruin your whole day

▼ ▼ ▼

By Patricia Barnes-Svarney

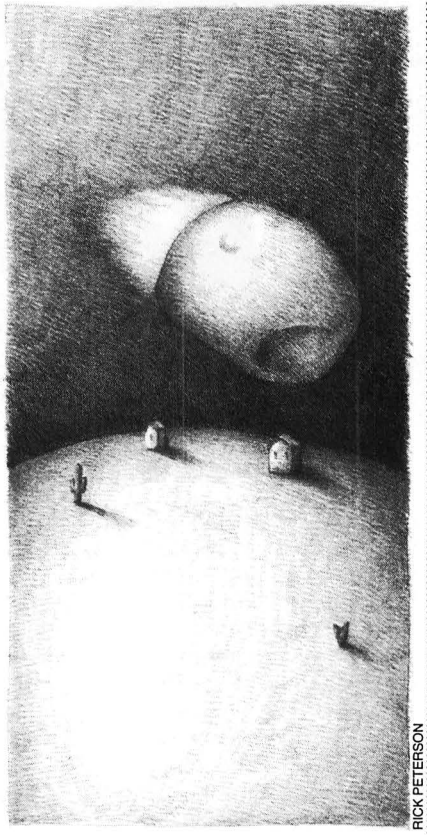
The Olympics isn't the only place where gymnastic events occur. Every day, asteroids, comets and all the other objects in our Solar System practice their own astronomical gymnastics, as they're pushed and pulled by the gravity of every other object. Occasionally, one of these heavenly bodies winds up in an orbit that brings it relatively near Earth. The result *could* be a close encounter—of the very large kind.

Spotting these "near-Earthers"—objects that either cross the Earth's orbit or come precariously close—has been Eleanor Helin's concern for nearly sixteen years. Helin, a research scientist at the Jet Propulsion Laboratory in California, became the principal investigator for Palomar Observatory's Planet-Crossing Asteroid Program in January 1973, and she's kept watch for these celestial vagabonds ever since.

Before the Palomar project started, only eight or nine asteroids were recognized as near-Earthers. Examining the existing photo plates, Helin searched for the tell-tale signs of near-Earthers: a long, dark line or trail on the photographic negative. "The trails would be there," says Helin, "but there would only be one plate, and never enough observations to (calculate) an orbit."

The Palomar program, funded by NASA and also supported by groups such as The Planetary Society and the World Space Foundation, has been a great success. For a portion of every month during the last 16 years, Helin and other interested astronomers have scanned the skies for these elusive objects using Mt. Palomar's 18-inch Schmidt telescope (the best type for finding near-Earthers). Helin exposes huge, six-inch photographic plates for six minutes at a time. When six or seven nights' worth of photos has been accumulated, she carts the plates back to the Jet Propulsion Laboratory to be analyzed.

In 1984, Helin established the International Near-Earth Asteroid Search, with the participation of astronomers using Schmidt telescopes in France, Denmark, Italy, the United Kingdom, Japan and several other countries. As soon as a fast-moving asteroid is sighted at one of the observatories, the positional data fly like lightning across the telex lines to all the others.



RICK PETERSON

Experts estimate there may be as many as 2,000 near-Earthers at least one kilometer in diameter, so Helin's search is like looking for the proverbial needle in a cosmic haystack. The size of the observable sky makes finding the objects a study in patience and persistence. Poor weather conditions and telescope operational problems also plague many of the sessions.

But Helin's sleuthing has paid off; her group has been responsible for 28 of the 110 confirmed sightings of near-Earthers. Occasionally her luck comes in bunches: in 1983, two of them were found within three degrees of each other on the same photographic plate.

Why the search for near-Earthers? "The original purpose," says Helin, "was to learn the extent of their populations and how close they are to the Earth. But since the beginning of the project, the reasons have multiplied."

Near-Earth asteroids are considered prime candidates for rendezvous or flyby missions by unmanned space probes, perhaps as early as the next decade. So far, Helin's group has discovered five of the ten asteroids under serious consideration. The ideal candidate is one whose orbit is in roughly the same orbital plane as the Earth's and is as circular as possible.

Close-up examination of a near-Earther could yield data banks full of information about the origins of the Solar System, and might possibly explain the existence of the asteroid belt that stands like a dividing line between the rocky inner planets and the outer gas giants. More enterprising scientists cite the feasibility of mining asteroids as a prime mover for a near-Earther rendezvous.

Another reason for the search is more sobering: we've been hit before by large space objects, and we can be hit again. "The hazard aspect is certainly a consideration, one that's always been there," explains Helin, "though there is a tendency to overemphasize that role. But there is the finite possibility of a strike.

"It seems every 25 years, something a few meters in diameter hits, with most of them striking a body of water," Helin continues. "The one that is going to be difficult to find is the one that sneaks up on us—like an object coming from behind the Sun."

What we might be able to do about it, of course, is still a matter for the science fiction writers. In the meantime, it's nice to know that someone is keeping watch at night.

Leaving Home

continued from page 27

and it was like looking at the hour hand of a clock. You just knew you were moving away from it; you couldn't quite see it move, but you'd look away and look back and it would have changed. I was fascinated by it. After we got the spacecraft checked out, there really wasn't a hell of a lot to do. We'd go through our lunar procedures, but you can only do that so long.

Final Frontier: Shortly after you left Earth orbit, there's some reference in the transcript to Herb Alpert music coming over the radio into your command module. Do you remember that?

Anders: I'm trying to think where the Herb Alpert thing came from. We had given [Mission Control] some records. I think I gave them a Tijuana Brass/Herb Alpert record.

Final Frontier: So you had Mission Control play music for you?

Anders: Yes, I gave them some stuff. In fact, in lunar orbit, the most notable thing that stuck with me was that I had given them [a record of] the Norman Luboff Chorale singing Christmas music that I liked. We were in lunar orbit, and they started to play this, and the spacecraft was rotating. In order to have good communications you had to select one of four antennas, depending on which one was generally pointed toward the Earth. As you rotated, if you waited too long, you got poor voice communication. As we listened to the music, apparently I didn't turn the antenna or something, and it started warbling. And it sounded really kind of eerie and extraterrestrial. Every time I hear "O Holy Night," I think about that experience. It was as if the chorus of angels were really singing it, but they'd decided to go somewhere else.

Final Frontier: In those times during the voyage when you'd gone through your checklist and the switches were all set, what were you doing?

Anders: Well, on the way back [to Earth] it became a bit boring. I was amazed. I said, "Here we are, way out here and you've got a great chance to look at the Earth...." You can look at the Earth for only so long, and pretty soon, you know, it hasn't changed much. So it was a two-and-a-half-day fall. I would put my feet in the hand rests on the shock absorbers of the seats, and I would cantilever myself out and lay back like I had my feet up on the ladder of a swimming pool, and just sit there and wait for the time to go by.

One time I decided I needed a little exercise. So I put my hands on some hand holds, and I started doing a frog's version of a pushup. I'd push with my arms against my feet. Then I'd push with my feet against my arm. So I started going like this. Well, pretty soon I got a rather discreet [call from Mission Control], "We're detecting some pulses on the accelerometer." I can't imagine what they thought I was doing. (Laughs)

Final Frontier: On your way to the Moon, Borman got very sick. Were you worried that they were going to abort the mission?

Anders: Well, once you're on the way, the abort is a pretty serious business. You've got to somehow kill off all that energy of the Saturn, and so going around the Moon with a sick guy is a hell of a lot safer (even if he's dead) than trying to stop and come back.

But...well, we were worried...I was worried for Frank. He was obviously sick. He maintains it was sleeping pills. I'll let St. Peter be the judge of that. But it didn't make the spacecraft too pleasant because he was going at both ends, and it's a very confined place, and there was this stuff drifting all over the place.

I was feeling okay, but, you know, if somebody threw up in your lap right now, you wouldn't feel too good. So I grabbed an oxygen mask for fire use only and stuck that on, because the smell was terrible.

It was ironic that I'd talked Frank into 'fessing up [to the ground controllers about being sick]. For whatever reason, I thought the ground people ought to know about it. So he finally divulged this into the [onboard] tape recorder. Then we gave what I thought was a very clear clue that the guys [on the ground] ought to go read out the onboard tape, which they could do. All they had to do was hit a few buttons and down it would come.

But we never heard from them. We kept waiting, thinking the world was going to erupt, and they were going to talk to Frank and recommend some antidote to whatever his problem was. After eight hours, we figured they really don't give a damn. By this time, Frank's feeling better. Christ, then eight hours later the world comes unglued. They finally got around to listening to the tape. It didn't make me feel too good. "What the hell? Are you guys really minding the store down there?" (Laughs)

Final Frontier: What else did you do when you had nothing else to do? Did you bring a book with you?

Anders: No; should have. I played zero-G—pour out a little water and watch it bubble around, or play with a pencil. But even that, after two and a half days, can get a little boring to sit there and flip your pencil. (Laughs)

It was difficult for me to sleep. I didn't feel sick, but I didn't feel great. Borman and Lovell were together on watch, and then they'd go to sleep, and then I was on watch. Basically it was Borman and Anders on and off watch, and Lovell went with Borman. And they talked a lot. Borman's half deaf, so they would yell back and forth.

Final Frontier: About what?

Anders: Just ball games, anything, how's this, how's that. They'd chat. So it was hard for me to sleep, because of the noise and because of zero-G. You lay in bed at night and felt yourself falling—that would happen a lot. Plus the fact that I didn't want anybody messing around with the systems. I remember every now and then, reaching up and grabbing Lovell's wrist, and he would say, "I thought you were asleep!" He was up there and had his hand near some switch. He seemed to like to throw switches. So I didn't sleep much.

Final Frontier: Did you have the window shades open all the time or did you put them down?

Anders: Mostly open except when you're trying to sleep. Now, also, the window [sealing] material oozed out, so our windows looked like somebody had smeared oil on them—very disappointing. It had an oily purplish look, like new, clean lubricating oil. In fact, when we were in lunar orbit for the first time—just before the engine firing, as we flew from darkness into sunlight—there were long shadows and some high promontories illuminated on the Moon. But I thought that it was oil on the window, running down in droplets, rivulets. I thought I was focused [on the window] and I was really on the lunar surface. What it *was* was the mountains of the Moon. I just blinked my eyes a couple of times and said, "Son of a bitch. That's the Moon, that's the back of the Moon."

Final Frontier: You were actually a little disappointed in the way the lunar surface looked.

Anders: Yes. It just wasn't as interesting as I'd expected. Pretty soon it became

clear to us that it wasn't at all like [the film] *2001,* rough and jagged. Intellectually I knew it shouldn't be that way, and I was surprised that I was surprised that it was as bombarded and sandblasted as it looked.

Final Frontier: Although you had looked at Lunar Orbiter pictures before your trip, hadn't you?

Anders: Yes, but they weren't that good. The Lunar Orbiter was further out. For some reason, I didn't expect the Moon to be as bombarded as it was. I mean, it looked like Verdun. It was just a mass of pockmarks.

Final Frontier: Most of what you saw in sunlight was the far side?

Anders: Yes. When we went the Moon was very new, and therefore we were able to see the back of it [in sunlight], more than anybody's seen it since. We've seen pieces of the Moon that nobody else has ever seen, at least in daylight.

But there's not a bit of it that hasn't been hit by meteors. Even the flat parts are battered. I mean it looks flat from here. You get up close, and we had a little monocular. You look through that and it doesn't look any different.

And there were no dimensions. I mean, literally, even the landing guys had a heck of a time telling how high and far away they were because there were no rivers, no barns, no fences or trees like a pilot is used to. All you had was your radar altimeter. The radar altimeter said you were at sixty miles or you were at six hundred feet. You look down, there's a bunch of holes. If somebody had said, "The crater's twenty feet across," you could believe them. If they said it was twenty miles across, you'd believe that too. You just couldn't tell. It made depth perception very difficult.

Final Frontier: In lunar orbit your main job was taking photographs of the surface, with specific features in mind?

Anders: Yes, the geologists, they wanted this, and they wanted that. What we really should have done is just turn all of the cameras on and let them go, as opposed to trying to match up this map with that particular feature. We brought back a lot of unexposed film, which was too bad.

Final Frontier: You didn't shoot all the film that you had?

Anders: No, we had probably more than half of it unexposed. There was a suggested checklist, and of course they said, "If you see things of interest...." But there was a film-rationing mentality that was, in retrospect, inappropriate. Then we got into a phase where Frank determined, probably with some justification, that everybody was getting tired. So he declared a moratorium [on taking more photos]. It made me a little unhappy, but no big deal, and the cameras were basically on a slow click every twenty seconds, or something like that.

Final Frontier: I read that section in the flight transcripts. For about twenty minutes he was yelling at you, "Goddammit, Anders, go to bed!"

Anders: Right. So I just laid there and watched out [the window] from my seat. I didn't have as good a view. I wasn't going to go to sleep.

Final Frontier: You never really slept?

Anders: Never, no. Didn't sleep, didn't really try.

Final Frontier: Until when? When you were coming home?

Anders: Yes. I probably didn't sleep more than eight hours the whole flight, and then it wasn't very good sleep.

Final Frontier: Why was Borman so upset about it?

Anders: In fairness to Frank, he was responsible for the mission. All our tails were on the line, but the Air Force has found in studying air crews that the guy who signed out for the airplane has a lot more stress on him. He's the one who has to answer if somebody screws up. In retrospect, it's not fair to second-guess him. I was unhappy at the time, but later I figured, "No great loss, what's a few pictures? The next guys will take them."

Final Frontier: The question has come up about which one of you took the first picture of the Earthrise over the lunar surface. Have you been through all that controversy in the past 20 years?

Anders: Right, and it's been conclusively proved. After the flight, [on goodwill tours] we often had a little "Frank, Jim, and Bill Show." Frank would tell this story—actually it's kind of funny except it kind of teed me off at the time—something about how he had to force the 70 millimeter camera away from me taking flight plan pictures so that he could take a picture of the Earthrise, which *wasn't* in the flight plan. Then, after he told the story many times, he started believing it.

There was a fellow by the name of Dick Underwood, who is sort of the guru of NASA photographers, and he's the one who really did the detailed research comparing the voice-tape versus what [camera] lenses were on. And there's no doubt about it. There was never any doubt in my mind that I took it.

Final Frontier: There's a line in the transcript where Borman says, "Hey, look at that. Get a picture of that," and you said something....

Anders: I was trying to [photograph] something else and I told him to hold off a second, and oh no, he had to have it right away, and there was a little bit of hassle back and forth....

Final Frontier: So Borman was the first one to see the Earthrise, but you all three then crowded around the window....

Anders: We're all looking out the window and I think we all...my guess is we all saw it about the same time.

Final Frontier: Same thing with the first close-up view of the Moon?

Anders: Yes. My impression is that either Lovell or I were...Frank was looking inside, and I think Lovell and I were looking outside. But I can remember before anybody said anything, seeing these streaks going down the window and thinking, and maybe even saying, something like "What's that?" and then realizing that it was the Moon.

One of the stories that I tell, which probably irritates the other guys—and I don't even know whether this is true but I've told it so many times that it's gotten to be one of those things I almost believe—is that I was actually the first one to go around the Moon. My story is that I was on watch, so I turned the spacecraft a little bit sideways so that I was going first by a hair's width. (Laughs) I don't know whether that's true at all, but I think it's a hell of a story, and any time I hear Frank Borman saying he took the Earthrise picture, I say, "Well, fine, but I was the first one around the Moon."(Laughs)

Final Frontier: What else do you remember about being in lunar orbit?

Anders: One aspect of the flight that I'm surprised hasn't been picked up on is the crew's naming of the craters. [Before the flight] I decided that I would name the craters. What the hell, we

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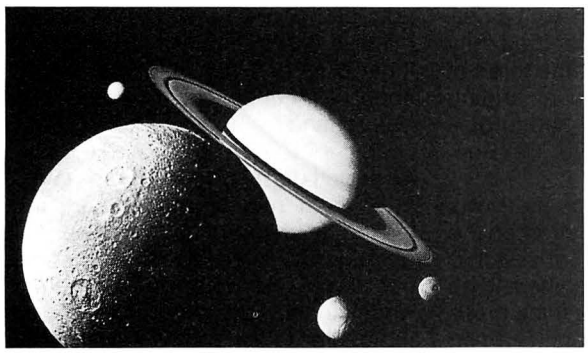

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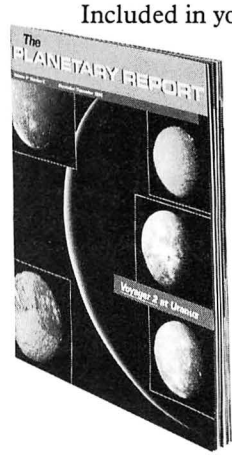

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were going there. I didn't ask anybody. I didn't even ask Borman. So I got a Lunar Orbiter map, crude as they were. And I can remember sitting there at the Cape one night coming up with a list of names that I thought would be politically acceptable, including the President and all administrators of NASA. I picked out a few nice ones for the [astronauts] who had died, and, of course, one for Borman, Anders and Lovell—and even made sure they weren't the biggest.

In training, we actually used those maps, and some of the training guys probably remember that we had a Crater Houston. It's even in the voice tape. You'll find us saying, "We're over Houston." The press never really picked up on that. Then, when the International Astronomical Union met and renamed the craters that we took pictures of, it always kind of made me mad. These guys weren't there. Who the hell did they think they were?

And to add insult to injury, they thought, I guess, that they were going to honor us by naming craters for six Americans who *weren't* dead. The naming of extraterrestrial features is generally not for anybody that's alive. But the astronomical union, with a certain, I think, properness, decided they would pick six Americans: the three of us and the three from the lunar landing crew. And, of course, they had to pick six Russians in order to get the Russians to agree.

But what really made me mad was that there was a little black sliver on the back side that we could not see into because there was no sunshine and no Earth-shine. Where do you think those guys picked for the Anders, Borman and Lovell craters? In that sliver.

A friend of mine was the president of the astronomical union, so I've written him about five or six letters, just sort of jabbing him, saying, "First of all, you guys didn't have the right to rename them." I got a letter back saying, in effect, "Gee we've already picked these names." I wrote, "Well, you should have at least picked craters we could see. Either you were vindictive or you're dumb!" He quit writing to me after that. (Laughs)

Final Frontier: Let's talk about probably the most famous moment of the mission, your reading of Genesis in lunar orbit on Christmas Eve. Did you spend a lot of time thinking about that beforehand?

Anders: I don't know how Frank looked at it as a religious message, but I looked at it more as, here we were going to be doing Mankind's first step out, and Mankind needed some sort of whack in the solar plexus besides just the photography and Walter Cronkite's description. This thing struck me as being very basic. Primitive isn't the right word—*fundamental.* Whether you believe God created the heavens and the Earth in five days or seven days, or whatever, is kind of immaterial. To me it's a fundamental theme that people can get shaken and awakened by. I think it did that to a degree, even for nonreligious people.

Final Frontier: It was powerful. Did you feel that at the time?

Anders: Yes, I did, and the photography, with the long lunar shadows, it all worked. It was well timed. Looking straight down at a crater would hardly have gotten anybody excited, but when you saw that Moon with the panoramas, particularly as you're going near the terminator, I think it amplified that this was kind of eerie, fundamental, really something different for mankind.

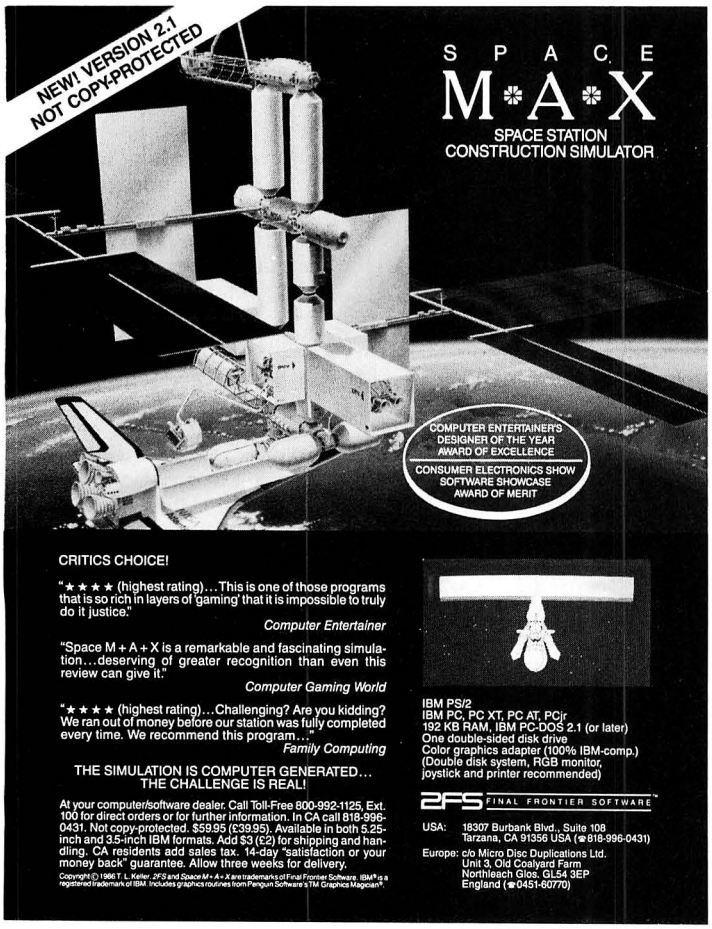
Final Frontier: Okay. Let's talk about the return to Earth. At some point you had to turn the capsule with your backs to the Earth for re-entry. When was that?

Anders: Much sooner than the flight plan, it seemed to me. Borman really wanted to get everything right. And, unlike Scott Carpenter, he wasn't going to wait until the last minute. I think we went into a re-entry attitude a third of the way back. I don't remember when it was, but it was a long time.

That's one thing I missed. I never really got to see the Earth getting big. We went rear-end-first several hours out. By that time you're really moving, because you just start going faster and faster and faster. So the last hour, you cover an awful lot of distance. You're moving at 25,000 miles an hour.

Frank's view was, "To hell with looking at the Earth. It won't do us any good to look at the Earth if we don't get set up for re-entry." And he was right.

Final Frontier: What do you remember



about the re-entry itself?

Anders: That it was impressive. Coming back in like you were a fly inside a blow torch flame. Then the night re-entry and landing. We hit [the water] very hard. I thought the space craft had split open because water came flying from everywhere. I guess it was [condensed water] coming off pipes [inside the cabin].

Final Frontier: Could you see anything in the water?

Anders: No, it was totally black; we couldn't see the parachutes or anything. All you could feel was a big "whump." Borman was momentarily stunned, and didn't flip a switch in time to shear the parachutes off, so we flipped upside down. And all the trash we'd collected then, it was like turning a New York City bus upside down; all this trash was right in our face. We're hanging there, and I thought, "Here we are, lunar conquerors, out in the middle of the Pacific in the dark, upside down with a face full of trash. Where's the justice in this?"

But we were bobbing around upside down and it was pretty rough. We finally re-righted the thing with inflatable bags on the apex of the spacecraft, and then we established radio contact. That's when somebody in a helicopter said, "Is the Moon made of blue cheese?" And I said, "No, it's made out of American cheese." That didn't get much play either. I thought it would, but it didn't.

Final Frontier: You trained for years, and went through lots of simulations before you went to the Moon. As momentous as the flight itself was, were there times when you thought to yourself, "I'm still in the simulator"?

Anders: Well, the actual flight is often considerably more dull. I found myself a couple of times thinking, before I'd catch myself, "Gee, I wish something would go wrong so I could show everybody how I can fix it."

Basically, we weren't very surprised during the flight except for the launch, and the difference between the Earth and the Moon. It wasn't like Verrazzano. He never even knew what was around the next reef, and he couldn't sit back there in Spain or Italy or wherever he came from, and go through a simulation of exploring North America. We'd simulated this thing over and over again, and trained and trained. We *weren't* just little automatic guys, but that's the nature of flight test. You don't *want* to be surprised. If you're sur-

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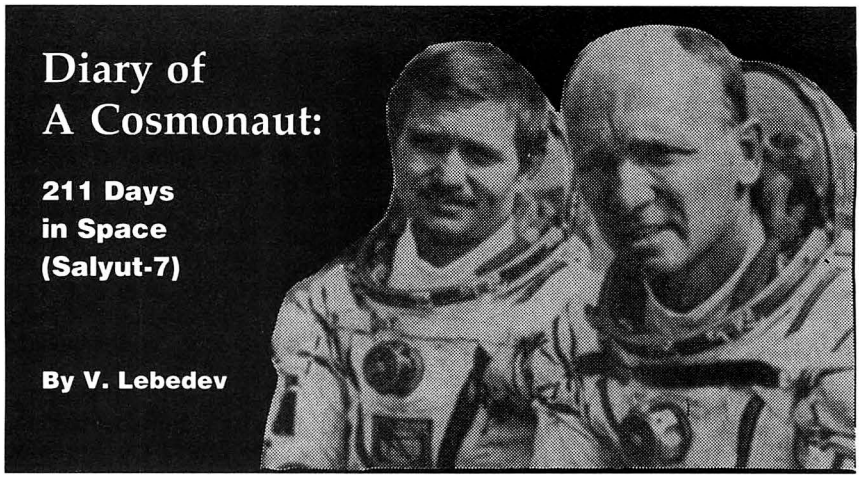

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prised, then somebody's probably screwed up in the past. But the public, you take them right out of being school teachers or grocers and stick them in there, they'd be surprised for every second.

Final Frontier: Today, when you're absorbed in company business, or some other unrelated thing, and somebody says, "Apollo 8" to you, is there a first image that comes to your head?

Anders: I don't think about Apollo 8 all the time. I can go for a whole month without thinking of it, and every now and then, when I see the Moon as a sliver, I'll think, "Son-of-a-gun, it's hard to imagine that I was out there. Is it really true?"

So Apollo 8 is not the first thing on my mind. It was a very thrilling, important experience, but now I have a family, a job and a life to lead past 1968. It's not the focus of my existence any more. But I think the image that comes to my mind most often is the view of the full Earth. It was that Earth that really stuck in my mind when I think of Apollo 8. It was a surprise; we didn't think about that. □

Pioneers

continued from page 21

Moon. As it left the atmosphere, it was moving at 23,500. The steering rockets added another 110, but no more. The third stage had failed to separate cleanly from the second, hanging up momentarily and deflecting itself from the proper direction. With its trajectory off and its velocity too low, Pioneer 1 would soar very high, reaching an altitude of 70,717 miles—nearly a third of the way to the Moon—but it would fall short nonetheless.

Its instruments were working, however, and the data came streaming in, regardless of where the probe was headed. This was true space exploration. As Pioneer 1 rose toward its peak, it touched the fringe of interplanetary space for the first time, measuring magnetic fields, radiation and micrometeoroids.

No one could sleep, not as long as the spacecraft continued to live. "We'd been up about eighteen hours," Booton remembers. "[Project leader] George Mueller came by and said, 'Where's the second shift?' I said, 'George, we don't have a second shift.'"

Twenty-four hours into the flight, Pioneer was past its highest point, falling with increasing speed toward the Earth. An attempt to put the spacecraft into a high, looping orbit of Earth failed when a firing mechanism could not be made to work, despite continued tries. Pioneer 1 thus continued its fall, retracing the path of its ascent. Forty-three hours after launch, it reentered the atmosphere over the south Pacific. The last anyone heard of it was from the tracking station in Hawaii. Its signal hadn't wavered, but had continued clear and strong. Then, with no warning, it stopped. Plunging into the upper atmosphere at six and a half miles per second, Pioneer disintegrated and burned up, leaving no trace.

The nascent Moon program had come so close to success that everyone could taste it. And for some, that was enough. Indeed, the feat was astonishing to much of the world. The Paris newspaper *La Croix* called it "the most prodigious event in history." A group of leading British scientists called it "amazing" and "a most tremendous achievement." India's Prime Minister Nehru, a frequent critic of the United States, declared it to be "a tremendous triumph of modern science." And closer to home, Simon Ramo, a cofounder of the Ramo-Wooldridge Corporation, offered his own perspective. "What we gained this weekend," he said, "was a few seconds on infinity."

The nascent Moon program had come so close to success that everyone could taste it. And for some, that was enough.

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But that turned out to be the emotional high-water mark in America's early efforts to reach the Moon. Pioneer 2 was launched with high hopes in early November; the Thor capably did its duty, but the Able stage failed to ignite, and the spacecraft eventually re-entered over central Africa. Wernher von Braun, whom Eisenhower had given the task of competing with the STL group, staged a near-replay of Pioneer 1 on December 6. Pioneer 3 needed a speed of 24,486 miles per hour, but came about 900 mph short. That was enough to send its payload to an altitude of over 66,000 miles, but not enough to escape the Earth.

Von Braun reached that milestone on his second try, in early March 1959. But the success of Pioneer 4, a tiny spacecraft weighing all of 13.4 pounds, was by then anticlimactic. Two months earlier, the Soviets had unleashed their monster rocket to hurl the 796-pound Luna I spacecraft past the Moon and into deep space. They followed in September with the first launch to hit the Moon, and a month later with the Luna 3 spacecraft that swung around the unseen lunar far side, cameras clicking away. Even today, the major features of this previously unexplored territory bear such names as the Sea of Moscow and Crater Tsiolkovsky.

After that stunning achievement, few would remember the bold attempt, a year earlier, of Pioneer 1, and it remains obscure even today. Yet Louis Dunn, George Gleghorn and their colleagues stretched the limits of space exploration. Their scientific discoveries were quickly superseded, and their goal—to orbit the Moon and return a set of images—was accomplished in spectacular fashion by the Lunar Orbiter spacecraft of 1966 and 1967. But Pioneer 1 still stands out as an exercise in boldness, decisiveness and willingness to try something new.

And for that alone, thirty years later, it deserves to be remembered. □

T.A. Heppenheimer has written dozens of books and popular articles on science and space exploration. His most recent book is The Coming Quake, *published by Times Books.*

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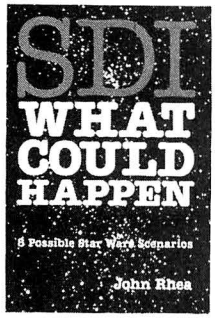

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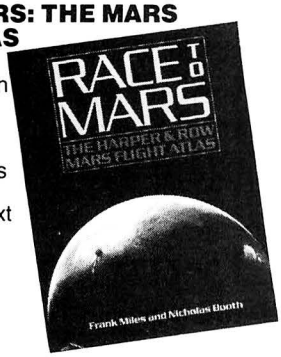

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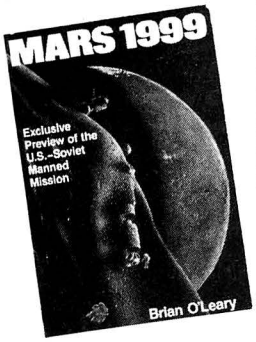

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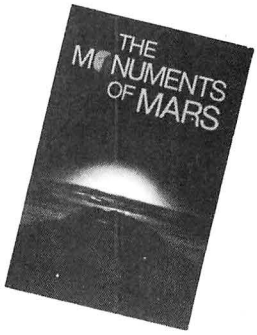

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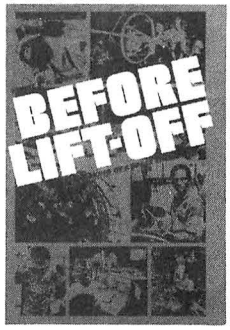

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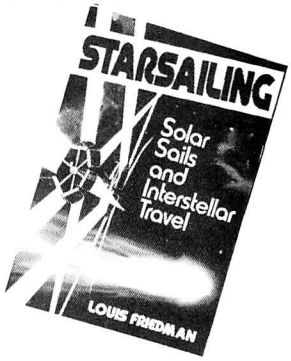

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Robonauts

continued from page 49

tem pioneers—rovers with wheels or even legs on which to explore the lunar or Martian surface. Robot arms will gather samples and repair data stations. Artificial intelligence programs—whose predecessors will have been developed for Earth orbital missions—will guide the new robots, providing enough instructions to avoid problems due to delays in communicating with Earth.

"Then the real question will be whether we *want* to have people in space," says Varsi. "And if so, why?"

Some visionaries see a time when the descendants of 20th century robots will not only explore the universe but populate it. Robot colonies would be sent to build habitats on other worlds so that humans could follow in comfort. Robots would spend decades "terra-forming" planets to make them more Earthlike, or fly off to distant solar systems as emissaries of mankind. They may even reproduce, building exact duplicates of themselves and passing on software to their "newborns."

The FTS will have a body—although it will probably look more like a piano than a person—and will have at least three arms.

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"You mention the word 'robot,' says John Oberright, "and you push a lot of deep-seated, psychological buttons in people," particularly among those who conjure up science fiction scenes of machines wreaking havoc on the population. Either that, or you get people who say that robotics is a bunch of hogwash that's a hundred years downstream.

"The reality is that neither is true," Oberright continues. "There isn't some technology hiding in a laboratory somewhere waiting to be discovered—what we have in front of us is a very challenging and exciting engineering job." □

Greg Freiherr is a freelance writer and consultant in Washington D.C. who specializes in aerospace and medical technology.

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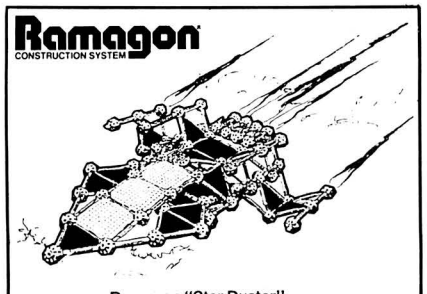

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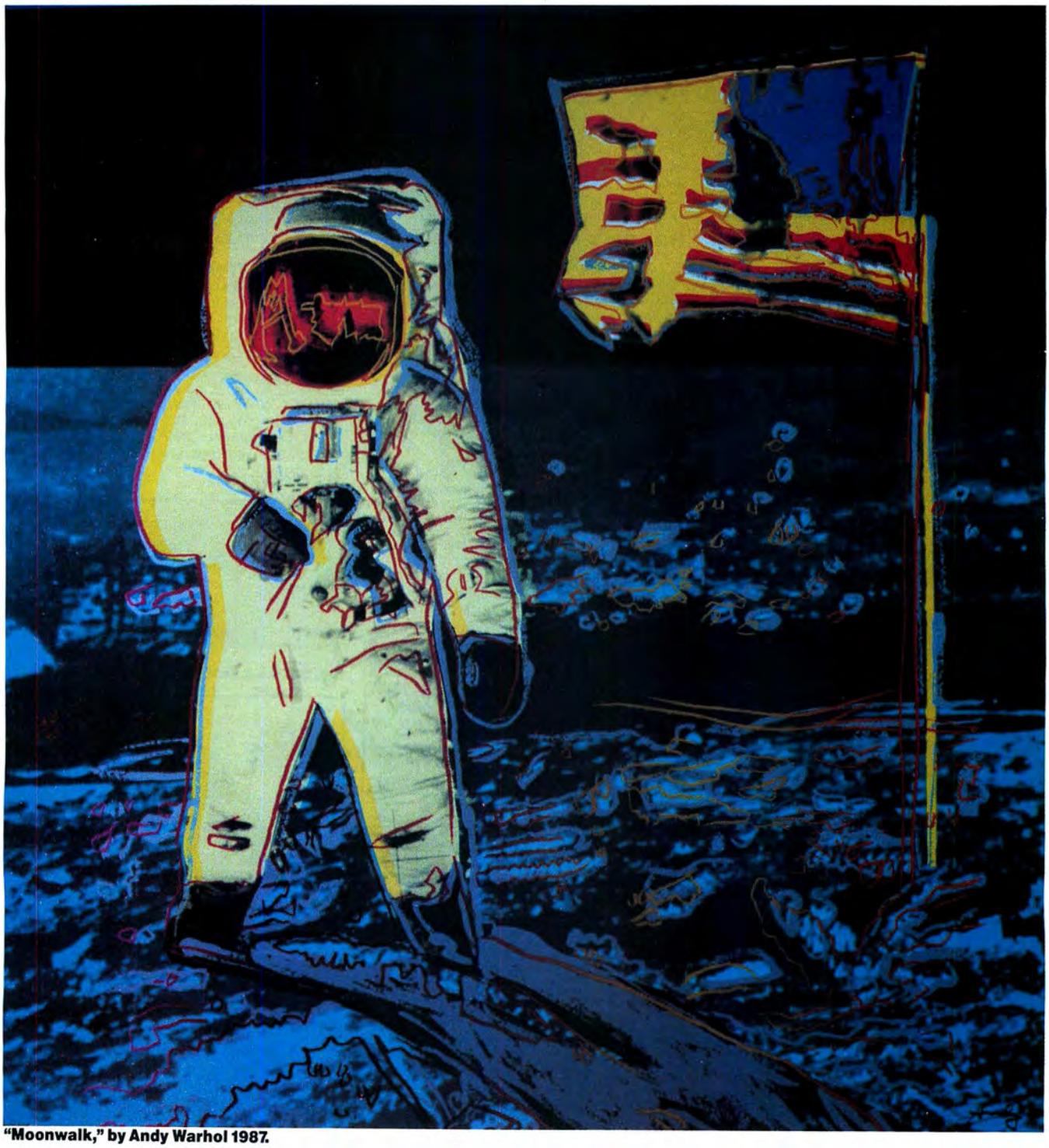

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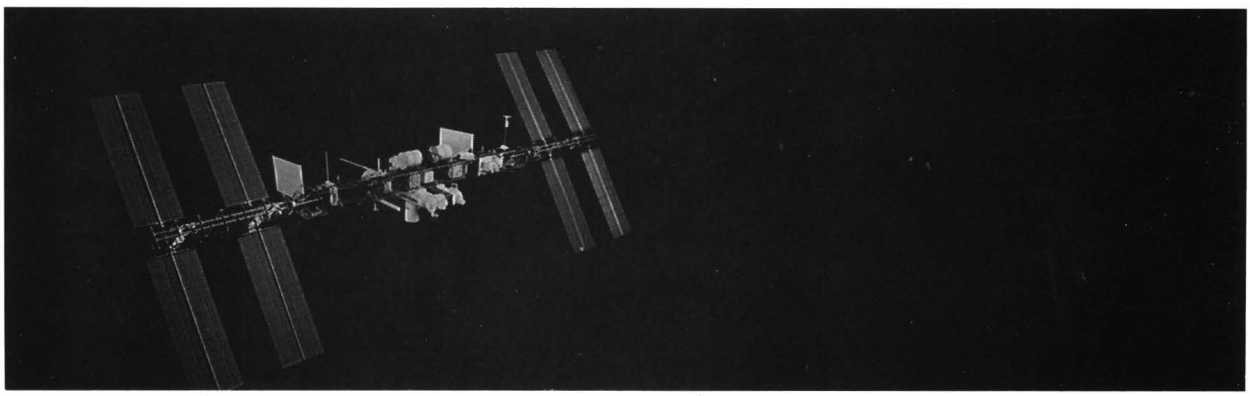

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